(Agricultural Series No. 22.)
(Fodders.)

THE

AGRICULTURAL LEDGER.

1901—No. 1.

PASPALUM DILATATUM.

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. I. P. 331a.*]

A NEW FODDER GRASS FOR INDIA:

Being information collected in the Office of the Reporter on Economic Products.



CALCUTTA:
OFFICE OF THE SUPERINTENDENT, GOVERNMENT PRINTING, INDIA.
1901.

Price 2 annas or 2d.

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THE

AGRICULTURAL LEDGER.

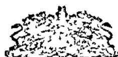
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The objects of THE AGRICULTURAL LEDGER are :—

(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers;

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept;

(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products to officials or other persons interested therein;

(4) To secure a connection between all papers of interest published on subjects relating to economic products and the official Dictionary of Economic Products. With this object the information published in these ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.

To facilitate the preparation of an index to THE AGRICULTURAL LEDGER, the following arrangements have been made, commencing with 1900 :—

All papers published will be paged, irrespective of subjects, into an annual volume.

The annual paging will be given on the top of the pages. But to permit of a continuation of the classification into the various series hitherto observed, a further folio will be shown at the bottom of the pages. This will be preserved throughout each series and be continued for several years, until in fact sufficient material in each series has been accumulated to constitute a fair sized volume.

At the end of the year a printed index and title page will be issued for the annual volume and after a period of, say, five years an index and title page will be issued for each series. It has been found that many persons subscribe for a certain series only, and do not care to receive the others. The new arrangement, while permitting of the formation of an annual volume, will at the same time retain the serial classification.

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AGRICULTURAL LEDGER.

1901—No. 1.

PASPALUM DILATATUM.

[*Dictionary of Economic Products, Vol. V.*, Pat. I., P. 331a.]

A NEW FODDER GRASS FOR INDIA :

Being information collected in the Office of the Reporter on Economic Products

Interest has lately been aroused in the fodder plant known to botanists as **Paspalum dilatatum**, *Poir.* The present accordingly seems a fitting opportunity to bring together in a convenient form the information on this subject which at present exists in the Office of the Reporter on Economic Products.

The late Baron Ferd. von Mueller, K.C.M.G., etc., in his work *Select Extra-Tropical Plants*, page 218, gives the following description of the plant:—"Extra-tropical, South America. Perennial, of excellent quality for fodder. Mr. Bacchus found it hardy in Victoria up to a height of 2,000 feet. It grew in New South Wales, after drought was followed by heavy rains, 4½ feet in little more than two months. It is closely allied to the Mexican **P. virgatum**, *L.*, introduced into Australia like many other fodder grasses by the writer."

An interesting article on **Paspalum dilatatum** by Mr. C. Sargeant recently appeared in *The Melbourne Leader.* The paper was subsequently reprinted by *Indian Gardening* in its issue of 27th April 1899, and is here given in full:—

"That large and fertile district in Gippsland, known as the scrub country is rapidly being reclaimed; but the conversion of these regions into valuable grazing and agricultural farms has not been easily accomplished. Very large sums of money have been lost by the early

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EXPERIMENTAL CULTIVATION

pioneers in finding out the most suitable grass to sow. At first rye grass and white clover [were tried], but the results were distinctly not favourable. The grass grew well enough, but could not resist the caterpillars Then a fresh start was made with cocksfoot, which proved an excellent grass, but failed in its turf-forming capacity. No matter how thickly it was sown, it has a strong tendency to thin out and become tussocky Thus the soil becomes too much exposed, with injury to the pastures during hot weather. The cocksfoot, being a shallow-rooted grass, suffers much from drought, and, further, is peculiarly liable to the ravages of the grasshoppers. Nothing can be said against the cocksfoot as a fattening grass, the finest lambs that enter the Melbourne market being from cocksfoot and clover pastures; while cows fed on it give excellent milking results. If this grass would only form a turf nothing could be better.

"At the beginning of last year *The Leader* drew attention to a new grass—**Paspalum dilatatum**—that had been cultivated with much success by the Agricultural Department of New South Wales. Being much impressed with *The Leader* statements, I at once set about obtaining some seed for testing, and the results, so far, are most satisfactory; so much so, that I have come to the conclusion that the introduction of this grass into the colony for the purpose of fodder and pasture is most desirable. While endeavouring to induce the farmers of this locality to look upon this plant as a grass destined to supplant the cocksfoot as the primary grass in our pastures, the contention was met with that the grass already existed in the district, and that it was a weed. Being satisfied that this was a mistake, and that the whole question was of too important a character to neglect, I determined to undertake a journey to New South Wales for the express purpose of examining and investigating the grass in the districts where it is stated to be successfully established.

"This necessitated a special visit to the north-eastern corner of New South Wales, where is situated the rising district of Wollongbar, on the Richmond River, a locality that is destined to become one of the most important centres of production in that colony. About ten miles beyond Ballina, the first port of call, the country begins to rise to about 400 or 500 feet above the sea. This country, which was originally covered with timber and dense jungle, has been, and is still being, dealt with in precisely the same manner as the scrub country of Gippsland, the soil and the general aspect being in all

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A New Fodder Grass for India. *PASPALUM* **dilatatum.**

points very similar. Wollongbar has lately come into prominence on account of the attention paid to the cultivation of artificial grasses, and foremost among those who have devoted their attention to this industry is Mr. H. Morton Williams, of "Florida," Wollongbar. Mr. Williams has been remarkably successful with the cultivation of the Paspalum dilatatum which, if appearance, growth, quality, and general results are anything to go by, certainly promises to become the queen of grasses for the dairy farmer and graziers generally. This grass is indigenous to Ceylon, and was first brought under the notice of Australians by the late Baron von Mueller, who strongly recommended it on account of its high nutritious qualities, and its drought-resisting properties, on which he laid great stress. Like many other things, very little notice was taken of the grass at the time. If any attempts were made to cultivate it, very little was heard of it. The first to introduce the seed into the Richmond River district was Mr. Edward Secombe, who procured a small parcel and succeeded in propagating it. No seed at the time could be obtained under 10*s.* to 12*s.* per lb. Mr. Secombe's experiments at once attracted the attention of Mr. Williams, who determined to give it a trial. Mr. Williams' holding consists of 100 acres, 60 of which is cleaned in the usual way, that is, by burning the cut scrub, and then burning off the logs Of the 60 acres, 7 acres are occupied with garden, orchard, stockyards and flats for testing seeds, leaving 53 acres under grass. Much of this contains large bare patches where logs have been burnt off, so that, at the outside, there are not more than 50 acres. And since last September 7 acres out of that have been continually shut up for seed purposes. Mr. Williams states that in the first instance he sowed Paspalum dilatatum, cocksfoot, rye grass, timothy, couch grass, alsyke and white clovers In addition to the Paspalum there are only small patches of cocksfoot and rye grass left. The Paspalum is asserting itself and gaining possession of the ground from which the other grasses have vanished. Having spent two days on the farms, and closely observed everything, I can from actual observation bear out all Mr. Williams' statements. He and others affirmed that the district was suffering from a four-months' drought, from October to the end of January, therefore it could not be said that things were under their best aspect.

NEW SOUTH WALES.

Success obtained.

"As showing the carrying capabilities of the Paspalum, the number of stock noted on the farm were 34 milk cows, 22 head

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PASPALUM *dilatatum.* A New Fodder Grass for India

EXPERIMENTAL CULTIVATION.

young stock, ranging from 12 months to 2 years old, 1 bull and 6 horses, making a total of 63 head. The whole of the stock were in excellent condition, and, as a rule, their condition was better than that of cattle fed on other grasses. A feature of the farm is the number of small paddocks into which it is divided, and the process of subdivision is still being carried out So rapid and continuous is the growth of the grass—assuming that it has a reasonable amount of rain—that the soundness of the principal of closing a paddock for a few weeks is fully demonstrated in the case of this remarkable pasture plant. It seems to possess exceptional vitality, together with sound constitution, and grows with great rapidity after a fall of rain. It should be noted that the whole of the grass seed on the farm was sown on the surface after the scrub had been burnt, and from a sample that was dug up for inspection I noticed that it presented a dense mass of fibrous roots, some of which were over 12 inches in length, showing that it grows no less vigorously downward than upward In deeply cultivated land it is a veritable deep sinker, and a grass that, if given an opportunity, is thoroughly capable of looking after its own existence. As a frost-resisting grass I was informed that when the sugarcane was entirely blighted the Paspalum only showed very slight signs of having been affected. Cows when turned in upon it from other pastures, soon show an improvement, and an increased yield of milk. Mr. Williams, who sends his cream to the local creamery, furnished me with the average test for each month for the past year, which may be looked upon as a good yield, considering that the cows are purely a scratch lot, picked up in the sale yards [illegible] no way selected :—For January 3·7, February 3·7, Mar[illegible] the whole [illegible] May 4·1, June 4·3, July 4·1, August 4·0, Sep-
determined to und[illegible] November 3·5, December 3·6. As to the
express purpose of examining [illegible] into hay, subjoined is an analysis
districts where it is stated to be s[illegible] applied by the Wollongbar Experi-
" This necessitated a special [illegible] total albuminoids 10·31 ; soluble
New South Wales, where is situat[illegible] buminoids, 8·93 ; digestive fibre,
on the Richmond River, a locality [illegible] 6·37 ; soluble ash, 4·32 ; insoluble
the most important centres of pr[illegible] pounds, 14·86. Total 100·00.
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to about 400 or 500 feet above th[illegible] that the Paspalum is a valu-
originally covered with timber and [illegible] ass and worth the attention of
still [illegible] wth. Where it will not grow
c[illegible] hat, provided it can obtain
P[illegible]

NEW SOUTH WALES

sufficient moisture, it will grow anywhere. It has been proved to grow in sand; also some planted near salt water, and inundated with it, was none the worse for the immersion The grass is certainly of most nutritious and succulent quality, and for an artificial grass, as already stated, it possesses wonderful vigour. It sheds its seed twice a year, and when the seed stems are in full bloom reaches as high as 5 feet, fresh stems still shooting from the crown in various stages of growth. My own experimental plot in Gippsland has plants now with stems reaching to the height of 4 feet 6 inches, and at the same time new shoots are rising from the crown. It is quite as strong and healthy-looking as that growing at Wollongbar, and its general bearing indicates that it has come to stay. Those who are in a position to speak authoritatively at Wollongbar, state most positively that it will carry a cow to the acre at the worst. Mr. Campbell, Inspector of experimental stations in New South Wales, is of opinion that its carrying capabilities would amount to an average of a cow and a half to the acre. Victorian dairy farmers will, however, no doubt be well satisfied with grass that will carry one cow to the acre. In this connection it may be reasonable to expect that in temperate Victoria during the winter months there may be a longer period of dormancy than in the sub-tropical district of the Richmond River. Experiment may show that such is the case on the south side of the Dividing Range in Victoria; but on the north side, specially in the Goulburn Valley and similar districts, where the winter is milder, the autumn growth may be prolonged and the spring growth earlier, especially if there is provision for flooding with water when required. It must be borne in mind that subdivision will be the keystone of success in dealing with this grass The experience at Wollongbar is that when a paddock is shut up for a few weeks, the grass at once starts to grow and recovers itself rapidly. With respect to the permanency of the Paspalum, Mr. Williams has a small paddock that he laid down four years ago, which presents a solid turf of green verdure. There is not a speck of the soil to be seen. The sight of this paddock is enough to convince the most sceptical as to the value of the grass. Owing to its capacity for forming a strong turf it will no doubt do much in keeping down weeds, and it may in a great measure successfully resist the bracken fern

"Like all artificial grasses, it may after a time be necessary to plough it up and re-plant. Of course the grass being quite new,

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Results of analysis.

quality of the grass when converte l into hay, subjoined is an analysis made by Mr. F. B. Guthrie and s applied by the Wollongbar Experimental Farm.—Moisture 10·55, total albuminoids, 10·31 ; soluble albuminoids, 1·38, insoluble a buminoids, 8·93 ; digestive fibre, 29·96, woody fibre, 27·95 ; total ash, 6·37 ; soluble ash, 4·32 ; insoluble ash (by difference), 2·05 ; amide co ipounds, 14·86. Total 100·00.

"From the foregoing it will be see that the Paspalum is a valuable fodder plant as well as a pasture gr ass and worth the attention of all who may have land suitable to its gro wth. Where it will not grow it is difficult to say. It may be accepted hat, provided it can obtain

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NEW SOUTH WALES.

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experience will have to be gained as to its proper treatment. There are two essentials to ensure the seed germinating, *viz.*, heat and moisture. If a reasonable amount of heat is not obtained, the seed may be dormant for some time. In any case it must not be expected that the whole of the seed sown will germinate for a certain proportion is barren. In laying down a pasture, from 5 lbs. to 8 lbs. of seed is necessary, but as little as 2 lbs. may be sown. In that case, when the grass reaches the seeding stage, it will be necessary to close the paddock to allow of the shedding of the seed. By that means the paddock will become fully grassed. To sow such a small quantity of seed, in order to obtain an equal distribution, it requires to be thoroughly mixed with a quantity of sawdust.

"The fame of the Paspalum has reached the other colonies, including New Zealand. Orders for the seed are coming from all parts to Wollongbar. For the purpose of raising a pasture, roots of the grass may be planted. The seed of the grass is difficult to save, owing to its not all ripening at once. As a consequence, it entails a great amount of time and labour in collecting it. There is no reason why the grass should not thrive as well in Victoria as it does at Wollongbar, except, perhaps, that there may be a greater deadness in the winter, for which an allowance may be made by reducing the carrying capacity. Any one who is in a position to run 100 cows may regard himself as thoroughly independent, and this, according to the New South Wales proven experience, with Paspalum, handled as described in this article, can be done on 100 acres of reasonably good land."

The following passages, taken from the Report of a meeting of the Agri.-Horticultural Society of India held on 13th December 1899, appeared in *Indian Gardening* of the 21st idem.

"In connection with the reference made by the Department of Land Records and Agriculture, Bengal, in August last, Mr. E. C. Whitehead sends the following —A report on a new fodder plant (Paspalum dilatatum) which can be grown with profitable results on all sandy wastes, by Mr. A. Crawford, the dairy expert of the Department of Agriculture, Perth, Western Australia, is published in the Perth *Western Mail* of the 26th May last The plant will, I think, prove an inestimable boon to us in this country, for millions of acres that are now to all intents practically useless would become valuable grazing properties. The fodder or grass, Paspalum

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dilatatum, will thrive even in the poorest soils. "At the quarantine station at Subiaco, two-and-a-half years ago at the beginning of summer it was planted in the poorest sandy soil with no manure and no attention. It grew well all the summer, and at the end it was found that it had put down its root 18 inches in the sand, and it was impossible to pull it up. It grew about 18 inches in height and kept growing the whole summer. Last year it was tried at Drakesbrook in good soil, but planted very late. The roots have not gone down so deep as in the sand, but they are strong and have a fine hold of the ground. The grass grew over 2 feet high, although it was planted just at the beginning of the summer, and had very little rain to give it a fair start. I planted it at Claremont in a better class of sandy soil, without manure, and, watered, it grew 3 feet 2 inches high in three months. I then cut it, and in 6 weeks it was over 2 feet high again. It had no rain or watering from the time of cutting. Some which I planted in the same kind of sand and did not water, grew 2 feet 9 inches and after cutting, and still without water, it grew 2 feet 10 inches, and was quite green at the end of the summer. Some sown in manured sandy soil and watered regularly, did not grow nearly as high, but threw out more leaves and was inclined to become tussocky. In all cases at the two experimental stations and at Claremont, it kept green and grew right to the end of the summer."

Mr. G. M. McKeown, Manager of the Richmond River Experimental Station, New South Wales, writes thus about it :—"It is probably the best fodder plant or pasture grass yet introduced into this district, resisting both heat and cold, and yielding enormous quantities of fodder; much liked by stock, and shown by analysis to be of excellent quality. Plants in drills 18 inches by 6 inches apart quickly reached 5 feet in height, a test cutting giving 13 tons 3 cwt. to the acre. From a seed plot sown on the 28th September in sub-soil land a second cutting was obtained on the 3rd June in the following year, weighing at the rate of 19 tons 4 cwt to the acre. Subsequent cuttings after saving the seed yielded over 14 tons to the acre. In deeply worked land at least three heavy cuttings may be obtained in the season. In all seasons good pasture may be obtained from this grass, if not overstocked, and once established, it stands well the grazing and trampling of stock."

Mr. H. Martin Williams of Wollongbar, New South Wales, remarks :—"Four years ago I sowed my first seed-bed, and my farm

EXPERIMENTAL CULTIVATION.

is now practically sown with Paspalum dilatatum, and the more I see of it the more I like it. Of course I have mixed other grasses with it, but the Paspalum is the basis of the pasture. It has proved itself a mainstay, *growing vigorously when the fierce heat had parched up every other grass. It stands drought well*, and frosts do not kill it, and I have even cut it down and run a fire over it, and after this severe treatment it has grown as vigorously as ever. Its feeding qualities for dairying are undoubted The quantity of seed to sow an acre is 5 lbs. to 8 lbs.

Mr. Sergeant, of Victoria, observes that he visited a farm consisting of 100 acres, whereon 60 acres are cleared and of that area 7 acres are taken up with garden, buildings, etc, leaving 53 acres under grass (Paspalum dilatatum) and other grasses. On this at the end of four months' drought, from October to the end of January, all the other grasses had disappeared, and yet it was carrying the following stock:—34 milk cows, 22 head of young stock from 12 months to 2 years old, 1 bull and 6 horses, making a total of 63 head. The farm was sub-divided into small paddocks, and the stock frequently shifted from one to the other. Mr. Crawford, after giving an analysis of hay made from Paspalum dilatatum by Mr. Guthrie, continues:—"This hay compares very favourably with ordinary hay, containing a large proportion of digestible and nourishing material. The best time for sowing is from July to September. The seed cost about 7s. per lb. A seed-bed could be sown and the plants divided and planted out later in the spring."

Conf. p. 4

It is understood that this grass (Paspalum dilatatum) has been tried recently in Tirhoot with some success. Bullocks are reported to be fond of the grass which in good soil runs to 4 feet. It is also believed to flourish on Usar or Alkali lands.

It is not improbable that in the near future the experiments made by private individuals and others with this grass may lead to useful results. At present there is a scarcity of seed which has to be obtained from Australia and America.

Under the heading "The Fodder of the Future," the *Madras Mail* reproduces the following particulars in its issue of the 8th November 1900:—

"Messrs. Law Somner & Co., 139-141, Swanston Street, Melbourne, Victoria, Australia, who are now in a position to supply seeds of

A New Fodder Grass for India.

PASPALUM dilatatum.

Paspalum dilatatum at 5*s*. 6*d*. a pound, postage, etc., extra, write as follows to the Secretary, Agri-Horticultural Society of India: There can be no question as to **Paspalum dilatatum** being an invaluable grass, and it is now being eagerly sought for, since it has passed the stage of experiment. It resists both heat and cold (withstands drought, and frosts will not kill it), yields enormous quantities of fodder, is much liked by stock, and is shown by analysis to be of excellent quality. A good many people have found a difficulty in getting the seed to germinate. In our opinion this has been due to their sowing at the wrong time of the year, and in some cases where very unfavourable seasons, droughts, etc., have occurred, after sowing. Never sow in the fall of the year, but choose the early spring and summer, just before the ordinary season's rains may be expected. The quantity of seed to sow per acre varies with the requirements; 5 lbs. to 8 lbs. per acre on well prepared ground will soon result in a good paddock. If 1½ lbs. to 2 lbs. per acre are sown, after grazing it should be held up about September, and allowed to grow on and shed all its seed naturally. It will soon spring up, and young grass, if anything like a favourable season takes place, will be fit to graze in May. We consider that allowing the grass to shed its seed is the very best and surest method of thoroughly establishing a pasture. When the plants are far apart, the grass grows into big tussocks, but as soon as the spaces are filled up, it forms quite as good a turf as any of the other grasses.

"There is nothing hard or wiry about this grass, it is soft and succulent and there is no part of it from the crown to the seed heads that the stock will not eat."

P. 331a.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series, those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

(Agricultural Series, No. 34.)
(Food Substances.)

THE

AGRICULTURAL LEDGER.

1901—No. 2.

(REPRINT FROM ORIGINAL REPORT.)

TRITICUM VULGARE.

(WHEAT.)

DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. IV., T. 634-834.]

AUSTRALIAN METHODS OF TESTING AND IMPROVING WHEAT:

THEIR APPLICABILITY TO INDIA, WITH SPECIAL REFERENCE TO THE PREVENTION OF RUST.

A Report by W. H. MORELAND, ESQ., I.C.S., *Director, Department of Land Records and Agriculture, North-Western Provinces and Oudh.*

Other PAPERS that may be consulted:
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TRITICUM VULGARE.

(WHEAT.)

DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. IV., T. 634-834.]

AUSTRALIAN METHODS OF TESTING AND IMPROVING WHEAT:

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A Report by W. H. MORELAND, ESQ., I.C.S., *Director, Department of Land Records and Agriculture, North-Western Provinces and Oudh.*

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(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers;

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept;

(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products to officials or other persons interested therein;

(4) To secure a connection between all papers of interest published on subjects relating to economic products and the official Dictionary of Economic Products. With this object the information published in these Ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.

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CHAPTER I.—INTRODUCTORY.

SELECTION OF WHEATS.

THE work that has been accomplished by the Agricultural Departments of the principal Australian Colonies towards the establishment of wheat cultivation on an extensive scale falls naturally into two divisions. The first thing to be done was to test existing varieties of wheat and ascertain their defects when cultivated in the different agricultural regions of the Colonies; the second step was the attempt to produce new varieties or races, the habit of which should be more suited to local conditions, while the produce should be such as to command a high price in the European markets. The advantages of the system of testing adopted and of the methods of producing new varieties have at different times been pressed on the attention of the Government of India, and during my stay in the Colonies I have been enabled, through the courtesy of the officers of

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the Agricultural Departments, to make a careful study of both systems · the results of my enquiries are embodied in this report.

2. But before entering on a description of the methods adopted it is desirable to state the direction in which progress is looked for. There are two great natural hindrances to the extension of wheat-growing in those parts of the Colonies which are at first sight adapted for the purpose: in some of the moister regions summer rust (Puccinia graminis) is extremely prevalent, and indeed has in some localities practically put an end to wheat cultivation: in the arid regions, on the other hand, rust is not a dangerous enemy, but any serious deficiency in the small rainfall of these parts involves the entire loss of the crop. Thus, so far as agriculture is concerned the objects sought are to produce wheats (*a*) that will resist or escape the summer rust, and (*b*) that will come to maturity with a minimum supply of moisture in the soil. The quality of prolificness is subordinated to these main objects as it is considered better to have wheats that are fairly certain to yield a moderate return, than to rely on races that will give a great harvest in favourable seasons, but little or nothing when conditions are adverse. Along with these qualities the nature of the grain receives special consideration, the object being to produce grain of the kind most appreciated by millers using roller-mills, and consequently fetching the highest price in European markets. This again involves the conditions that the grain shall be fairly easy to mill and shall give a high percentage of flour, which must be "strong," rich in gluten, and of the colour and texture for which bakers are prepared to give the highest price. Another important quality is the possession of stiff straw, as any weakness in this respect interferes with the use of mechanical harvesters and the condition of the labour market puts hand reaping entirely out of the question.

3. It will be apparent from the above description that the qualities most desired in the Colonies are not in all cases important in India: it is not possible therefore to take Australian results ready-made and conclude that the varieties finally approved in the Colonies may at once be recommended for use by Indian cultivators. And even if the qualities required in the two countries were in all respects identical, there is another objection to the transfer of approved races from one to the other; the fact is that races of wheat are apt to change their character when transferred from one locality to another,

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even when the obvious conditions are not very dissimilar. Our knowledge of the life of any plant is confined to such a small portion of the whole that it is impossible to tell beforehand what will be the result of a transfer; all that can be done is to determine by experiment whether the sum total of the conditions present in the new country is favourable to the plant: and the result of such an experiment can be conveniently stated by saying that a variety is, or is not, adapted to a particular locality. I shall have occasion to use this expression later on, and I wish it to be understood merely as indicating that the resultant of the conditions in that locality is on the whole favourable to the variety. At any rate two facts cannot be disputed, (*a*) that in order to decide whether a given race of wheat is suited to a particular agricultural region it is necessary to test it in that region, and (*b*) that any marked change of conditions usually results in such a change in the character of the race as to materially alter the balance of important qualities. We cannot therefore take the facts ascertained in Australia and apply them to India: if an attempt is to be made to improve the nature of our wheats, it will be necessary to do the work ourselves: but we can adopt the methods that have succeeded elsewhere with a reasonable expectation of favourable results. Before improvement is taken in hand it is desirable to have definite knowledge of the advantages and defects of the wheats already grown, and a clear understanding of the qualities at which we should aim. The following chapter will therefore deal with the methods of testing.

CHAPTER II.—METHODS OF TESTING.

SELECTION IN AUSTRALIA.

4. In New South Wales, which leads the Colonies in this matter, the testing of varieties is carried on first in the field, and secondly *in the laboratory. Nothing much need be said as to field trials:* the system is well known in India, and a note explaining how it can best be carried out in existing conditions has been recently published in the Agricultural Ledger of the North-Western Provinces and Oudh (*vide* Bulletin No. 8 of 1900). The varieties selected for trial are sown in plots of uniform capacity; the plants are watched carefully during the critical periods of growth and the behaviour of each variety noted with special reference to any particular features (such as the amount of moisture available, the tendency to rust, liability to shed the grain before harvesting) that may be of importance

Field-tests.

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in the circumstances. At the same time information is collected from practical cultivators who are accustomed to grow the variety on their holdings. When such trials and enquiries have been conducted, and the outturn of grain determined, over a series of years long enough to afford a fair sample of the climate that may reasonably be expected, it becomes possible to pronounce an opinion as to the relative suitability of the different varieties for the locality, or rather the agricultural region, where the experiments have been carried out.

5. It is, however, necessary to remember that the conclusions drawn from such trials are not of wide-spread or general application. Each agricultural region must stand by itself, and the varieties *suitable to it must be determined by direct experiment within its borders*. In New South Wales, experimental farms exist, I believe, in every region that can be recognised as having a distinct climate, and the best varieties can thus be determined for each region.

Laboratory tests.

6. The system of laboratory testing employed in New South Wales (*a*) requires more detailed description, as, so far as I know, nothing like it has been attempted in India. It may be premised that (with the exception of certain wheats specially suited for making macaroni, and consequently commanding a high price in the markets of Southern Europe) practically the whole of the wheat produce of the Colony is destined to be converted into flour in roller-mills of the modern type. Hence the tests applied are directed towards ascertaining the presence or absence of the qualities specially appreciated by the miller and the baker. A report on a given sample of wheat is drawn up in the following form:—

(1) Variety of grain.
(2) Appearance of grain.
(3) Weight per bushel (lbs. per bushel).
(4) Ease of milling.

(5) Percentage of mill products { Flour. Pollard. Bran.

(6) Nature of flour . . { Colour of flour. Strength of flour (quarts of water per sack of 200 lbs.). Percentage of dry gluten.

(*a*) I am indebted to Mr. W. M. Guthrie, F.C.S., Chemist to the Agricultural Department of New South Wales, for the opportunity of studying these tests in the laboratory in his charge.

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The first head gives the name of the variety as submitted (*b*) and the second describes the appearance of the sample, an important matter as millers are accustomed to judge grain to some extent by the eye. The third head—weight per bushel—is important where the cumbrous system of selling grain by the bushel (or quarter) of so many pounds prevails: were the trade conducted (as in the interior of India) purely by weight, this heading would be of no importance.

The ease or difficulty of milling is important from the miller's point of view: with some varieties the flour can be readily separated from the other products, in others it adheres to the bran and repeated operations are necessary. Ease of milling cannot be determined objectively: the report on this point is the opinion of the experimenter based on his observations of the process, and consequently it contains a subjective element.

To ascertain the percentage of mill products, the sample of grain is put through a miniature roller-mill, under conditions as nearly as possible similar to those which prevail in practice; and the percentage of the various products determined by actual weighment. These figures are of course most important to the miller, who will (*cæteris paribus*) pay a higher price for wheat which gives a higher percentage of flour.

The colour of the flour is judged by pressing part of the sample so as to present a smooth surface and then moistening it; the colour and quality of the surface are then compared with standards and named accordingly. I understand from the experts who carry out these tests that colour has not been found to be uniformly correlated with any really valuable quality in the flour; the colour is tested because bakers prefer a flour of a particular colour.

Similarly the "strength" of flour is important mainly from the baker's point of view. A flour is said to be "strong" in proportion to the amount of water it will absorb: to the baker this simply means that a given weight of a strong flour will bake into a larger quantity of bread (by weight) than the same quantity of a weaker flour, or in other words that he can make more or larger loaves from the same weight of a strong flour than from a weak. Recent investigations

(*b*) The nomenclature of the varieties commonly grown in the Colonies has been authoritatively determined by a conference: new varieties produced by Mr. Farrer are named by him as soon as they are fixed.

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show that the strength of flour depends on the constitution of the gluten. Gluten contains two proteids (known as glutenin and gliadin) which occur in very different proportions in different flours; and the greater the proportion of glutenin to gliadin, the stronger is the flour. The chemical composition of these two proteids is very similar, and it has not to my knowledge been shown that their nutritive values are appreciably different; but the strong flours offer some advantages to the consumer as well as to the baker. "The loaf produced by a strong flour is a better one, the process of fermentation is more uniform, and a better-risen and better-aerated loaf is the result, yielding consequently a more digestible and wholesome bread" (Mr. W. M. Guthrie in the Agricultural Gazette of New South Wales, October 1900, page 865). It will be seen that the advantages of strong flour *to the consumers* arise when the European method of baking is followed: they would be much less important, if they exist at all when the flour is baked into flat unleavened cakes as is usually done in India.(c)

The proportion of dry gluten in the flour is a different matter, as the nutrition-value of flour may be said to vary directly with the percentage of gluten; this test therefore, unlike those which have just been mentioned, must always be applied when it is desired to compare the real value of different flours. The method by which this proportion is determined is given in the footnote (d).

Cost of Laboratory-apparatus.

7. The cost of complete apparatus for carrying out these tests would probably be from £50 to £60; the roller mill alone would cost about

(c) The method in use for determining the strength of flour is thus described by Mr. Guthrie in the paper quoted above—

[illegible]

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£40. The tests can be applied only by a person who has had special training: the Agricultural Chemist, who is in charge of the work, estimates that a man of good abilities with fair general scientific knowledge would require four months' training in the laboratory before he would be qualified to work independently.

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8. By this dual system of testing, first in the field and then in the laboratory, complete information is obtained as to the value of each strain or race of wheat. The first set of tests shows the character of the plant, the yield of grain, the power of withstanding drought, and of escaping or resisting rust, and the other qualities the sum of which shows whether or not the race is adapted to the particular agricultural region. The laboratory tests show the value of the product when placed on the market, and they secure that undue weight shall not be attached to mere productiveness irrespective of the quality of the produce. The system, as a whole, is admirably adapted for use in a country the produce of which is destined to be made into bread by European methods, and its value is highly appreciated in the Colonies: but for certain reasons it is not entirely suitable to India. The explanation of these reasons requires a consideration of the objects of wheat growing in India.

Australian methods not entirely suitable to India.

9. So far as wheat is grown for European consumption the object of the Indian cultivator should be to get the maximum yield of wheat giving the best quality of flour (estimated as is done by up-to-date millers): where artificial irrigation is available the crop is practically independent of drought, so that there is not the same reason as in the Colonies for preferring a hardy to a prolific variety, and the whole attention of the cultivator can be given to producing the greatest weight of grain of good quality. In dry tracts, on the other hand, the quality of drought-resistance becomes of the utmost importance. The danger of rust also exists: in some parts of India, such as the Gangetic duab, the varieties now grown as a rule suffer little actual loss from rust, having apparently become adapted to the locality in this respect: but elsewhere, particularly in the Central Provinces and the Bundelkhand districts of the North-West Provinces, rust-resistance appears to be an essential quality of any race; and there is every reason to think that new races introduced into country like the duab (where existing races appear to be more or less immune) will be particularly liable to be attacked by the fungus.

Qualities important in Indian Wheat.

10. If then most of the wheat grown in India were intended for

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the European market, the New South Wales system of tests might be applied in its entirety and the expense of training operators and setting up the necessary machinery would be justified by the importance of the work that could thus be accomplished. But, as a matter of fact, the wheat produce of India is destined for consumption in the country: in exceptional years when a good harvest coincides with a period of high prices in Europe, the export of wheat reaches a total which, absolutely, is enormous; but even then it is only a fraction of the total production, and, taking the figures for a long series of years, the fact becomes apparent that the Indian market is much more important to the cultivator than any other. It becomes therefore necessary to enquire what are the characters required in that market.

11. Under present conditions of social life (and they are not likely to change very rapidly) the bulk of the wheat consumed is ground into *ata* (that is, meal rather than flour) in the ordinary stone hand-mill, and the meal is baked into unleavened cakes. Most of the laboratory tests employed in New South Wales thus become irrelevant, the only one of indisputable importance being the proportion of gluten. The other qualities important to the consumer are ease of grinding in hand-mill, loss in grinding, and certain conventional matters affecting colour and texture which probably differ in different localities.

Suggested Tests for Indian Wheat.

12. It seems to me then that the testing of wheats for growth in India can be effectively carried out as follows: there must of course be field trials, on the lines already described, for each agricultural region; and there should be some simple tests of the produce. The simplest of all is a valuation by grain dealers, if trustworthy men can be found, and by educated consumers: and this can be supplemented by tests of the gluten-content (which could doubtless be carried out in the Dehra Dun Laboratory), and by a practical milling test in a standard hand-mill, a very simple affair which could be done at any experiment station. Such tests would be sufficient to determine the suitability of produce for the Indian market; if it is considered that the prospects of the export trade from any regions are so great as to make it necessary to pay special attention to the needs of millers, then it would be desirable to set up a testing mill of the kind employed in New South Wales, and to have an operator trained to use it; in that case it would probably be most convenient to have the work done at

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the Dehra Dun Laboratory. Judging, however, from those parts of the country with which I have a personal acquaintance, the export trade in wheat is not of such relative importance as to make the introduction of these tests essential.

CHAPTER III.—Scientific breeding of improved races of wheat.

Means of Improving the race.

13. When it has been ascertained by some of the methods discussed in the preceding chapter that the race or races of wheat grown in any agricultural region suffer from certain defects: being either comparatively unproductive, or liable to injury from disease or irregularities of season, or yielding produce of a kind not liked in the market: the next step is to introduce an improved race. The first attempt in this direction is usually to import into the region some variety that has been successful elsewhere: this may or may not succeed, but for reasons that have been explained in the first chapter success is not antecedently probable, and in any case it is purely a matter of chance. The alternative is to breed new varieties more suited to local conditions; and it is in this direction that so much progress has been made in the Colonies, particularly New South Wales. The subject was there taken up by Mr. William Farrer, who worked at first independently and for the last two years as a Government officer. I have to express my warmest thanks to Mr. Farrer for the very great kindness and generosity with which he has placed at my disposal the whole of the method and results of his work; he has taken the greatest pains to explain every point of the elaborate system which he has devised, and has given me ample opportunities for practical work on his own breeding-grounds.

Selection without Breeding.

14. The principles which lie at the foundation of Mr. Farrer's work are well known to science; they may be called improvement by selection and production of variations by means of crossing. The first principle is that which was followed by the earlier breeders of "pedigree" wheat, and the method ordinarily adopted was to pick out the individual plants or even individual grains which possessed in the highest degree the special characters which it was desired to increase; to sow the seed of these and from their produce pick out the most desirable plants; and to proceed in this way until eventually a race was established having the desired characters in a markedly greater degree than the parent variety. The objections to this

Selection slow and selected race liable to revert.

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procedure in the case of wheat are two: the natural variations are comparatively few and small, and the improved race tends to revert to the condition of the parent variety when the process of selection is no longer continued.

15. The first of these objections appears to follow from the structure of the ear. It is common knowledge, as a result of the work of Darwin and others on the subject, that cross-fertilisation tends to produce variability in the offspring now the flowers of wheat are fertilised by their own pollen while still closed and at a time when extraneous pollen cannot enter the unfertilised flower, so that cross-fertilisation very rarely if ever takes place under natural conditions. The flowers being self-fertilised, the offspring reproduce the character of the parent in general with great accuracy, and marked variations such as form the most satisfactory starting point for selection are rarer than would be the case if cross-fertilisation were usual. The second objection greatly limits the value of improvements accumulated by selection alone; such improved breeds can be trusted to maintain their character only if the seed-stock is periodically renewed otherwise they gradually deteriorate Farmers can grow them if they are in a position to obtain regular supplies of seed from growers who devote their time specially to selection; but where other conditions prevail (as is certainly the case in India) the introduction of improved breeds produced by selection alone can be at most a temporary benefit.

Breeding of new Wheats.

16 The system followed by Mr. Farrer starts with the production of variations by artificial crossing. Leaving out all details of technique, it may be described as follows: having decided to mate two varieties, the unfertilised flowers of one are carefully castrated and are then pollinated from the other. The seeds thus produced are carefully saved, and sown by themselves · the produce of this (the first) generation is again saved plant by plant, and again sown separately It is in this, the second, generation that the greatest variability appears: and a glance at a row of plants of this generation is sufficient to show the very marked degree of variability which characterises them. From this generation any plants showing the characteristics specially desired are picked out for seed and the regular process of selection follows with the offspring until after some years a race has been developed which possesses these characteristics in a high degree. The tests already described are of course applied

Method of obtaining and fixing new breeds.

OBTAINING NEW WHEATS.

to the produce, and if the race is found suitable it can be recommended for general use; or it can be used as the parent of other varieties to be produced in the same way. The time required for "fixing" a new race varies greatly: some come true after three or four years, while others continue to show marked variability for a much longer series of generations, but it is an important fact that these races, unlike those produced by selection without previous crossing, appear to be permanent, and so suited for use by persons who save their own seed.

Influence of locality on new breeds.

17. In all this work the influence of locality has constantly to be borne in mind. Mr. Farrer prefers, when such a course is possible, to grow some at least of the produce of "the first generation" in that particular place or places for which the breed is designed; and to have the process of selection, commencing with the second (or variable) generation, carried out in that locality. When owing to the absence of the necessary facilities this cannot be arranged, and the selection is made in some other region, the process cannot be relied on to give such sure results.

Some rules for breeding.

18. It is not possible to reduce the whole breeder's art to rules: knowledge of the behaviour of individual varieties is necessary to enable a proper choice of parents to be made, and this knowledge can be obtained only by practical experience ranging over a number of years. Mr. Farrer has laid down the following principles as embodying some results of his experience:—

(1) Fairly good results can often be obtained by mating varieties almost at random, provided they be of different types.

(2) Better and more certain results can be obtained if the parent varieties have been chosen for possessing, even though it be only in a moderate degree, as natural attributes, the qualities which are wanted.

(3) While the best results of all will follow from the crossing of varieties which, while they possess naturally in the highest degree which has been obtained, the quality or qualities which are desired in a still higher degree, have had these qualities temporarily increased in them by a preparatory course of selection.

19. In carrying out the process of selection the cardinal rule is to take the plant as a unit; and to sow the produce of each selected

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procedure in the case of wheat are two: the natural variations are comparatively few and small, and the improved race tends to revert to the condition of the parent variety when the process of selection is no longer continued.

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with old where all were growing together. As it happened, the season during my visit was very dry, the moisture in the soil was quite insufficient and most of the well-known prolific varieties of wheat were suffering very much: alongside of them were to be seen newly bred races growing under exactly similar conditions but in almost perfect vigour and health. A detailed inspection of the plants was to my mind quite conclusive of the advantages possessed by the new races as drought-resisters. The second set of facts was observed during a visit to the hot and dry regions in the north-west of the Colony. This country is used mainly for stock-raising, but occupiers usually like to have a few acres under crops, which, however, with a rainfall of ten inches or under, the record of the last few years, are a very doubtful speculation. At the time of my visit to this part of the country the wheat should have been coming into ear, but had generally been ruined by the drought, so that what was left in the fields was being fed off by stock. Thus in that region the ordinary wheats were practically an entire failure: but some of Mr. Farrer's wheats grown under the same conditions succeeded as is shown by the following extract from a letter of the Manager of the Coolabah Experimental Farm: "We have harvested Mr. Farrer's wheats and they were satisfactory, many having very fair grain." I admit that this result surprised me, for the soil on this farm is naturally in a wretched condition, and it appeared to me hardly possible that it could supply enough moisture for any cereal to mature in such a season.

23. The success attained may be attributed to a combination of three elements; the system itself is sound, a sufficient number of farmers are ready to try new varieties, and the right man has been found to do the work. Of the soundness of the system there can be no doubt on scientific grounds; but it might have happened that the results obtained were nullified by the conservatism of the farmers. That quality, however, though still in evidence, has been pushed into the background by the severe calamities that have visited the Colonies. Thus the continued prevalence of rust practically annihilated wheat cultivation in the coastal districts of New South Wales; and in the dry country drought bid fair to prevent the establishment of the industry. It has become obvious that many of the wheats ordinarily grown are hopeless, and that the only chance of continuing to cultivate the crop is the adoption of varieties better suited to the conditions that prevail.

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A Report on Australian Methods

OBTAINING NEW WHEATS. Conditions in India which may determine the possibility of success. Conservatism of Indian farmer and prejudice.

24. In considering then whether the system of scientific breeding should be introduced in India the question arises whether there is any chance of the cultivators accepting new races of wheat. The Indian cultivator is popularly credited with a degree of conservatism unusual even among farmers in this respect, but he is not without excuses. In the first place, a man with a small holding cannot possibly take the risk of an experiment, the failure of which will mean, not a decrease of the balance at the bank, but an actual deficit in the food-supply of his family; and in the second place, it must be admitted that some kinds of seed largely distributed by the Agricultural Departments in past years have proved to be unsuitable to the needs of the country, and have therefore given some grounds for prejudice. It is necessary to be quite sure that we have improved varieties to offer before we can be sure whether or not the cultivators will accept them: and I do not think the Department has sufficient experience in the introduction of undoubted improvements to justify the conclusion that cultivators will not accept varieties which are obviously better than those in common use. In my opinion then the conservatism of the cultivator is not a sufficient reason to justify the rejection of the system of scientific breeding: but it is a factor of the problem that must be borne in mind, and its existence makes it desirable that the initial work should be done on a moderate scale and with no avoidable expense.

Need of an Expert.

25. I have ventured to name the personality of Mr. Farrer as the third cause contributing to the success of his work, it is questionable whether we can count on securing so much skill and devotion for work in India At the same time work would be started with some obvious advantages: Mr. Farrer had to work out practically the whole system for himself, while we have the full benefit of his experience; we have also the power of getting routine-work efficiently performed at a trifling cost

26 On the whole then, while it would undoubtedly be most satisfactory to employ an expert enthusiast and give him a perfectly free hand, it is very doubtful if the expert enthusiast would be found, and it would not be proper to go to so much expense if the work can be carried on by an adaptation of existing agencies. As I have just said, the routine-work presents no difficulty; success must depend mainly on the accumulation of an organised and available body of knowledge regarding the behaviour *as parents* of a large number

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OBTAINING NEW WHEATS.

of varieties. In New South Wales such an organised collection of knowledge is possessed by Mr. Farrer, but it seems hopeless under existing Indian conditions to rely on continued personal work, and it becomes necessary to substitute a detailed record of such knowledge to be made as acquired, thus extending as far as possible the dominion of routine and requiring as little as possible in the way of judgment. At the same time I hope that among the men employed we may find some one with the habits and interests which are the best equipment of the breeder, but my object is to rely on these as little as possible. The scheme which seems to me on the whole most suitable is outlined below, it being premised that the estimates of cost are necessarily somewhat provisional.

Scheme for a Central Station for breeding new Wheats.

27. On grounds of economy and general advantage, I recommend that—at the start at any rate—there should be one central breeding station for the whole of India. The principal advantages of centralization are that the accumulation of information will be more rapid and that the whole of it will be readily available. The work at this station would be limited to breeding and to the processes of selection which are a desirable preliminary (*cf.* paragraph 16). The rest of the work would be carried out by the provincial departments: that is to say, the examination and study of existing varieties, and the ascertainment of their defects must be done locally for each agricultural region where wheat is an important crop. The results of these enquiries would be intimated to the officer in charge of the central breeding station who would endeavour to produce new races of wheat generally suited to the locality in question and not so liable to the defects that had been detected. Seed of the new races would then be sent to the provincial department for trial and selection *in the agricultural region concerned.* These proposals involve that there shall be an experiment station of some sort maintained by the provincial department in the agricultural region where improvement is contemplated; but a large farm and an expensive establishment are not necessary. The amount of land required for a selection station will hardly ever be more than two acres: and the work of marking the plants for selection could be taught to any official of moderate intelligence in the course of a month's training at the central breeding station.

Connection with provincial departments.

Staff.

28. The work of breeding can be carried out by any one with a good general education, a practical knowledge of botany and a taste

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OBTAINING NEW WHEATS. Conditions in India which may determine the possibility of success. Conservatism of Indian farmer and prejudice.

24. In considering then whether the system of scientific breeding should be introduced in India the question arises whether there is any chance of the cultivators accepting new races of wheat. The Indian cultivator is popularly credited with a degree of conservatism unusual even among farmers in this respect, but he is not without excuses. In the first place, a man with a small holding cannot possibly take the risk of an experiment, the failure of which will mean, not a decrease of the balance at the bank, but an actual deficit in the food-supply of his family; and in the second place, it must be admitted that some kinds of seed largely distributed by the Agricultural Departments in past years have proved to be unsuitable to the needs of the country, and have therefore given some grounds for prejudice. It is necessary to be quite sure that we have improved varieties to offer before we can be sure whether or not the cultivators will accept them: and I do not think the Department has sufficient experience in the introduction of undoubted improvements to justify the conclusion that cultivators will not accept varieties which are obviously better than those in common use. In my opinion then the conservatism of the cultivator is not a sufficient reason to justify the rejection of the system of scientific breeding: but it is a factor of the problem that must be borne in mind, and its existence makes it desirable that the initial work should be done on a moderate scale and with no avoidable expense.

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inspection duties, I am of opinion that I could give sufficient supervision to ensure a proper start of operations. After the first year occasional visits to the station would be sufficient.

OBTAINING NEW WHEATS.

Initial Work and Expansion.

32. As a commencement, the breeders would be employed in the study and selection of various wheats, and in making those crosses which appear likely to give rise to new wheats with drought-resisting and rust-escaping characters, specially suited for the Central Provinces and the Bundelkhand districts of the North-Western Provinces. The work would gradually expand as requests for improved wheats arrived from other provinces or localities, and meanwhile both the supervising officer and the breeders would, by their detailed study of a large number of varieties, be gradually acquiring the experience which is needed as a foundation for successful work. Probably if the breeding station is a success, that is to say, if good wheats are produced and the cultivators take to them, it will be necessary to put the whole work in charge of a qualified European: but in that case the expenditure would be amply justified by results, and the question does not arise at present.

Provision of Cost.

33. I believe that by the scheme which I have outlined above, a scientific breeding station can be established at the lowest possible cost, and in such a way that expansion can be provided as required; the annual cost which would at first be about Rs. 1,000 and would rise gradually as increments accrue, as well as the initial cost of a storehouse, could presumably be met from the budget of the Imperial Agricultural Department; the cost of cultivation would hardly be susceptible of separate calculation and may fairly be met from the allotment for the Cawnpore Farm in the provincial budget of the North-Western Provinces and Oudh: in return for this small provincial expenditure the Agricultural School (or College when one is established) at Cawnpore will be provided with admirable facilities for the practical study of agricultural botany. The work of selection from the seed supplied by the central station must necessarily be done by the provincial department interested.

CHAPTER IV.—Observations on the prevention of rust.

PREVENTION OF RUST.

Extreme Localization of quality of rust-resistance.

34. Turning now to the special subject of rust-prevention, the orders deputing me to the Colonies indicated—

(1) that I should endeavour to obtain a supply of rust-resistant varieties of wheat for use in India:

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(2) that I should study the methods adopted for the prevention of rust.

Varieties proved rust-resisting in Australia may not be so in India.

As regards the first point, I have decided that it would be unwise to bring over any large stock of rust-resistant varieties. My chief reason for this decision is that the climate and agricultural conditions prevailing in India are so different from those of the Colonies that it is not possible to infer that a resistant variety in New South Wales will show the same character in India. Mr. Farrer and all other competent judges lay particular stress on the extreme localization of the quality of rust-resistance, and consider that that character can be secured only by selection within a particular locality. At the same time Mr. Farrer has very kindly promised to send me the offspring of crosses that appear likely to succeed in India, in order that they may be added to any breeding establishment that may be set up; and he has also made some crosses specially for Indian use.

Want of complete knowledge of Rust-fungus in India.

35. The second object of my deputation was the study of the methods adopted for the prevention of rust; the results of this study are recorded above in the description of the process by which new varieties with particular qualities are produced. In applying these methods to the production of rust-resistant varieties, it is necessary to bear in mind that the natural history of rust, whether in India or Australia, is not completely known, and that the work must consequently be to some extent empirical. We do not know for certain what form of rust is to be guarded against; and we certainly do not know the complete life history of the organism or organisms which are most destructive in India. Until therefore the scientific study of the organisms has made considerable progress, the process of producing rust-resistant varieties must be based on systematic breeding from those varieties or individual plants which, as a matter of fact, escape rust in a season when other varieties, or the other individuals of the same variety, are attacked. The proposals submitted in the preceding chapter provide fully for this work.

Typical characteristics of Australian ...ist-...ng

36. In choosing the parent varieties for this purpose, it will be desirable to pay special attention to the results of Australian experience as regards the features of plants which render them more or less liable to rust. Mr. Farrer enumerates the typical characteristics of a rust-resistant plant as follows (*f*) :—

(1) The straw and foliage should have a covering of close

(f) The enumeration in the text differs slightly from that published by Mr. Farrer ma[ny] years ago and reproduced in the Agricultural Ledger, the differences are [re]sult of increased experience.

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texture, and be well glazed, and well covered with bloom of a dark glaucous colour.

(2) The growth should be spare rather than gross.

(3) The flag and foliage, in addition to being well glazed and of close texture outside, should be erect, narrow and stiff, not heavy, broad and flabby.

(4) The *time* of maturity should be early: this character enabling a variety to develop before the onset of the stem- or summer-rust.

(5) The characters enumerated above are all subject to the condition of locality, in other words there is a power of rust-resistance, as yet undefined, which for the same race of wheat varies with the locality.

It cannot, in the absence of experimental data, be said to be proved that these conclusions, derived mainly from the study of Australian conditions, apply in their entirety to India; but what is known of the general habits of the rust organisms makes it highly probable that the same features will be found of advantage wherever rust prevails. While therefore the breeders should not aim merely at the production of the first four of the characters just enumerated, careful notice must be taken whether these characters exist in the plants that escape infection, and probably the best results will be secured by starting work on those varieties which, on the whole, conform most closely to Mr. Farrer's description.

Rust and *Drought may* work together. A Wheat *might be* bred to resist both.

37. I believe it is the case that those parts of India where rust is most severe are also most liable to suffer from drought; certainly this is so as far as the North-Western Provinces are concerned. Rust is rarely more than a slight calamity in any part of these provinces except in the Bundelkhand districts, which are notoriously most liable to suffer from any failure of the rains. Now for practical purposes it is obvious that the most desirable wheat for general use in such localities is one that will resist rust and at the same time be able to exist on a small quantity of moisture. Whether such a wheat can be produced by scientific breeding is a question for experiment; but it may be noticed here that none of the characters enumerated by Mr. Farrer require a great supply of moisture, while the moderate growth, and the narrow, hard flag are features that would usually be associated with the wheats of a dry region. There is therefore no reason to suppose that rust-resistant wheats will be specially liable to

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suffer from drought; and there is a possibility that they may be specially adapted to resist it. The possibility of producing such varieties is to my mind in itself sufficient justification for establishing a breeding station on the lines which I have recommended. (*g*)

CHAPTER V.—SUMMARY AND CONCLUSION.

SUMMARY.

38. In conclusion I may summarize my recommendations as follows:—

(*a*) The adoption of the New South Wales system of testing the value of grain appears to be unnecessary so far as the Indian market is concerned. If it be considered desirable to adopt the system with a view to the export trade, it would be sufficient to have one testing establishment for the whole of India which might be located at the Dehra Dun Laboratory.

(*b*) The system of scientific breeding can be introduced at a very moderate expense and with fair hope of valuable results. The most suitable arrangement would be to have a central breeding establishment at Cawnpore, placed at the outset under my control, and in direct communication with the different provincial departments. It will be for provincial departments to decide in what respects their local wheats are deficient; the central station will on request breed wheats such as may be expected to be an improvement on those in use, and will supply these to the provincial department: the latter will arrange for the cultivation and selection of the new breeds, so that these processes may be carried out in the agricultural region for which the wheats are intended.

(*c*) The trifling expenditure incurred in this work of selection should be borne by the provincial departments, the Imperial Government providing the cost of the central breeding station.

(*d*) The first work of the central station should be an attempt to produce wheats that will, as far as possible, stand

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(*g*) To avoid the possibility of misconception I may explain here that the

drought and resist or escape rust; the future developments will depend on the reports received from the various departments NEW WHEATS.

39. It only remains for me to place on record my gratitude for the ready assistance which I have received during the progress of my enquiries in the Colonies. In particular I have to acknowledge aid and information received from the following gentlemen:— Acknowledgment of Services.

The Honourable Mr. J. Fegan, Minister of the Department of Mines and Agriculture, New South Wales:

The Railway Commissioners of New South Wales:

D. C. Maclachlan, Esq, Under-Secretary, Department of Mines and Agriculture, New South Wales:

P. McLean, Esq, Under-Secretary, Department of Agriculture, Queensland:

W. M. Guthrie, Esq, Agricultural Chemist, Department of Mines and Agriculture, New South Wales:

H. Pye, Esq, Principal of Dookie Agricultural College, Victoria:

J T. Valder, Esq., Principal of the Hawkesbury Agricultural College, New South Wales:

The Managers of the Experimental Farms at Coolabah and Bathurst (New South Wales) and at Westbrook (Queensland):

and finally I must again express my warmest acknowledgments to Mr. Farrer for his great kindness and his cordial willingness to supply me with all the information at his disposal.

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All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

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(PEPPER.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. I., P. 811-20.*]

CULTIVATION OF PEPPER IN THE BOMBAY PRESIDENCY.

A further account of Manures used in Spice Gardens.

By J. MOLLISON, ESQ., M.R.A.C., *Deputy Director of Agriculture, Poona.*

Other PAPERS that may be consulted:

The Agricultural Ledger, 1898, No. 7; 1900, No. 3.



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GREEN MANURING OF PEPPER.

[The Survey Commissioner and Director, Land Records and Agriculture, Bombay, having furnished this office with a copy of Mr. Mollison's report No. 547, dated the 7th October 1900, (on the above-mentioned subject) the following extract from it is given as a supplement to *The Agricultural Ledger* No. 3 of 1900. The additional information will be found to include enumeration of those trees, the leaves of which are commonly used for leaf manure, as well as the chemical analysis of the different kinds of leaves, manures, and soils by Dr. Leather, Assistant Agricultural Chemist to the Government of India. The information thus furnished may be found of interest as a contribution to the large question of GREEN MANURING] *Ed.*

Sources of Green Manure.

The more common trees in *bela* lands and in protected forest, which are specially useful to the cultivators, for manure purposes, are referred to in short detail below:—

Kaval or Kavla (*K.*)* (Careya arborea, *Roxb.*)—Leaves big, fleshy, soon rot as green manure, and considered specially good for leaf-mould. Trees abundant in *bela* lands.

* (K) indicates that the name is Kanarese, (M) that it is Malayalam.

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AGENTS

In London.

E. A. Arnold, Esq, 37, Bedford Street, Strand, W. C.

Messrs Constable & Co, 2, Whitehall Gardens, S W.

Messrs. Sampson Low, Marston & Co., St Dunstan's House, Fetter Lane, E C.

Messrs P. S. King & Son, 2 and 4, Great Smith Street, Westminster, S W.

Messrs Luzac & Co, 46, Great Russel Street, W C.

Messrs Kegan Paul Trench, Trübner & Co, Charing Cross Road, W C

Mr. B. Alfred Quaritch, 15, Piccadilly, W

Messrs. Williams and Norgate, Oxford.

„ Deighton Bell & Co, Cambridge

On the Continent

Messrs R. Friedländer & Sohn, Carlstrasse, 11, Berlin, N W.

Otto Harrassowitz, Esq, Leipzig

Karl W. Hiersemann, Esq, Leipzig

Ernest Leroux, Esq, 28, Rue Bonapat Paris

Martinus Nijhoff, Esq, The Hague

In India

Messrs. Thacker, Spink & Co, Calcutta and Simla.

Messrs. Newman & Co, Calcutta

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„ Higginbotham & Co, Madras

Superintendent, American Baptist Mission Press, Rangoon

E Seymour Hale, Esq, Fort, Bombay

Rai Sahib M Golab Singh & Son Mufid-l-Am Press, Lahore.

Messrs A. J. Combridge & Co Bombay

GREEN MANURING OF PEPPER.

is produced. In course of time the tree dies prematurely by exhaustion or ill-health induced by bad usage. The pollarding practised unquestionably shortens the life of trees. It will also diminish their full value when dead, because they have spent their substance in producing by unnatural treatment leaves and small branches instead of natural growth. But the result justifies the means, because small branches and leaves are specially required by the gardeners. And if young trees of suitable varieties are so protected that they replace old decayed trees, and if pollarding is prohibited until young trees attain certain dimensions as proposed by the Committee in the draft rules, then I think the interests of Government will be fully safeguarded, and the requirements of the gardens fully maintained I saw numerous instances of well-managed *beta* lands. I saw also instances of ruthless destruction with the surface burnt to encourage grass, and no forest undergrowth to speak of, but side by side with these badly managed *beta* lands there was even greater destruction in protected forest for which the people at large, and not the garden owners alone, were responsible.

Dead leave will not do.

4. It is suggested in the papers that the full requirements of the garden occupants could be met if they gathered dead leaves and grass in enclosed forest to supplement the supplies of green leaves and twigs got from assigned *beta*. It is also urged that the dead leaves and grass would not be less valuable for manure than green leaves and twigs. I cannot support these views Leaves, as they become perfected, dry up and become fibrous and a good deal of the plant food, both mineral and organic which they contained when green and growing, passes from them and is utilized in increasing the size of the stem or branches and in perfecting the fruit. There can be no question at all, therefore, as regards the superiority for manurial purposes of the green leaves of a particular tree over the dead leaves from the same tree. The dead leaves fall, moreover, at a particular season and have to be collected at that particular season; otherwise they soon become incorporated with the soil and disappear. If put in deep pits they would in the course of a year decompose into what is known as a leaf-mould by gardeners. This material would, in my opinion, have inferior manurial value to the manure now used. I am convinced that such would be the case from the results of analyses by the Agricultural Chemist to the Government of India of the various descriptions of green

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leaves and small twigs ordinarily used. I sent him the leaves and twigs of eight different varieties of trees, being such as are considered best for leaf-manure. The analyses are appended below :—

Analyses of leaves and twigs used.

	Careya arborea	Bassia latifolia.	Pterocarpus Marsupium.	Xylia dolabriformis	Terminalia Chebula.	Dillenia pentagyna	Terminalia paniculata).	Terminalia tomentosa.
Moisture . . .	80 66	78 95	78 77	73·31	77·77	87·06	75·06	81·86
Dry matter . .	19·34	21 05	21 23	26 69	22·23	12·94	24·94	18·14
Organic matter .	18 00	19·60	19·58	25·24	20·90	11·68	23·42	16·74
Mineral matter .	1·34	1·45	1 65	1·45	1·33	1·26	1·52	1 40
Silica	·08	·10	·12	·11	·04	·08	·12	·07
Potash (K_2O) . .	·43	·43	·53	·44	·30	·41	·40	·44
Phosphoric acid (P_2O_5) .	·086	·087	·095	·08	·078	·070	·100	·080
Nitrogen . . .	·31	·43	·45	·62	·40	·24	·42	·34

Analyses compared with cattle-manure

5. The leaves and twigs contained from 73 per cent. to 87 per cent of water. But even in this succulent condition the percentage of nitrogen and potash (the two most important elements of plant food) were equal to about half the quantities usually found in well-preserved farmyard manure. The air-dried material of these leaves and twigs would be considerably richer in nitrogen and potash than air-dried well-preserved cattle-manure. The leaves and twigs are all deficient in phosphoric acid. The contention of the gardeners that certain leaves are better manurially than others is not supported by the analyses. *Hirda* leaves are considered locally very superior for leaf-manure, also those of *matti* and *honne*. But the analyses show that other varieties are superior to these for manure purposes. On the other hand, it is fair to state that the leaves of *hirda*, *matti* and *honne* are considered specially valuable, because the manure produced from them destroys insects and grubs which would be harmful to the plants in the garden. These leaves and in fact nearly all the leaves used by the gardeners have astringent properties, and it is, I think, certain that vegetable matter containing astringent resins or volatile oils would be obnoxious to insects and therefore insects or grubs which might be harmful to the plants of the garden would not harbour in such material. Dry leaves, unless collected soon after they have fallen, undoubtedly harbour insect life, and this is one serious objection to their use as manure. I was hopeful that the Agricultural

Analyses do not bear out the gardeners preferences.

Reason of preference.

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in the Bombay Presidency. (*J. Mollison.*)

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Chemist would be able to state definitely how far the various leaves and twigs submitted for analyses differed in astringent properties. He was, however, unable to investigate this point. I took no samples of dead leaves, because at the time of my visit to Kánara (April) it was impossible to collect samples which could be identified as belonging to any of the particular trees from which green leaves are usually taken. In fact dead leaves had mostly disappeared by that time. I believe they mostly fall in December-January, and could not, except in trifling quantity, be collected during the monsoon when green leaves and twigs are ordinarily collected as manure.

Means of improving the green manure.

6. Dr. Leather's analyses clearly indicate that manure of good quality can be made from the green leaves and twigs ordinarily used. The system of trampling the leaves under the feet of cattle, so that the urine and solid excreta are absorbed would improve the quality of the manure particularly if the cattle are fed partly on cake as is sometimes the case. The storage of manure in deep pits formed in soil and subsoil, which is very retentive, can hardly be improved upon excepting that the extremely heavy rainfall of the district must keep the unprotected pits excessively wet during the monsoon, and probably valuable manurial ingredients are washed out of the manure at this season.

Frequency of application.

7. The Kánara system is to apply manure every second year.

Analysis of manures.

8. I submitted to the Agricultural Chemist to the Government of India four samples of manures. Each sample is sufficiently described in the tabulated statement below :—

	Monsoon green leaf-manure. Sample taken from roots of trees to which it was applied in February 1898	Green leaf-manure as	Dry leaf-manure made	Manure made from green
Moisture . .	55 07	58·05	56 90	59·72
Dry matter . .	44 93	41·95	43·10	40·28
Organic matter .	23·44	28 74	25·42	26·48
Mineral matter .	21·48	13·21	17 68	13·80
Sand . . .	14·69	7 80	11·43	7·47
Potash (K_2O) .	·16	·41	·43	17
Phosphoric acid (P_2O_5) . .	·14	·18	·12	·17
Nitrogen . .	·51	·51	·55	·75

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It is difficult to understand the deficiency of potash in the 4th sample. The nitrogen and phosphoric acid are probably about average for this kind of manure Samples Nos. 1 and 2 were originally of similar class to sample No. 4. They were, I imagine, superior in quality originally to No. 4. No. 1 sample (taken in handfuls *from many trees) is by no means exhausted 14 months* after application, and it may be inferred from this that the gardener's methods of application and of protecting the manure from surface wash and heavy rainfall by a covering of branch-wood and leaves are successful in practice. From personal observation, I can say that the branch-wood, a full year after being first put on, is sufficient to break the force of heavy downpours of rain, and when first put on or afterwards allows the rainfall to percolate through the manure to feed the plants. It is suggested in the papers by one officer that the gardeners should use the leaf-sheaths of the *supári* palm (Areca Catechu, *Linn.*,) leaves as a protection for the manure instead of the branch-wood now used. The leaf-sheaths are all required for another purpose in the garden economy, and in any case the manure does not (as Mr. Davidson points out) need a water-proof. It needs protection and needs also to soak up the rainfall, as it falls in a fair and reasonable way.

Slow exhaustion of green manure under protection of branch-wood.

9 No. 2 sample was taken in the same way as No. 1 in handfuls from above the roots of many trees. The samples were taken two months after application. No. 2 contains less sand than No. 1 for obvious reasons, and probably its original manurial elements had been since application utilized to considerable extent, as the trees and plants were in active growth. The garden soil and the manure were quite moist, and there had been rather abnormal heavy rainfall some little time before the samples were taken. These are conditions which would help the plants to utilize the manurial ingredients quickly. The sample No. 3 from dry leaves used as litter under cattle is quite as good as might be expected. It has about half the manurial value of good cattle dung manure. The owner considered it was poor stuff. The high percentage of sand is noticeable.

Success of the present expensive system.

10. There is no doubt that the present system of manuring in the Kánara Gardens is successful in practice, provided the gardeners are allowed to use in sufficient quantity the kinds of forest produce which they prefer. The system of manuring is expensive, even

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though the materials are got free, and the destruction caused to forest growth is enormous. Under the circumstances, it would, I think, be most advisable to test by experiment whether available concentrated manures, such as castor cake or safflower cake, could take the place of a portion of the manure now used. These cakes can be imported from Dhárwár at reasonable rates into the district. Castor cake is less valuable manurially than safflower cake, and is dearer. In the Gardens of Bassein, with heavy rainfall in light soil, castor cake is successfully used. It is obnoxious to insect life, and if used in the Kánara gardens there would probably be less damage done by grubs and borers, which certainly do considerable damage to the garden plants and trees now. ALTERNATIVES.

11. I append hereto analyses by Dr. Leather of samples of four descriptions of soils which are sufficiently described in the appended tabular statement :— ANALYSES OF PEPPER SOILS.

	Kagadali earth, *e.g.* [illegible]	Earth from rice [illegible]	[illegible]	Soil from new extension of an old garden.
Lime (CaO) total	·11	·09	·15	·19
Magnesia (MgO) total	·30	·30	·29	·38
Alkalies total	1·07	·31	...	...
Potash total	·154	·071	·110	·27
Potash (K_2O) available	·003	·008	·004	·005
Phosphoric acid (P_2O_5) total	·086	·04	·073	·074
Phosphoric acid available	·001	·0017	·0005	·0015
Nitrogen total	·014	·20	·09	·18
Nitric acid (as Nitrates)	·0009	*Nil.*	*Nil.*	·003

12. Dr. Leather says the samples are all deficient in lime phosphoric acid and more or less so in available potash. I should, as a matter of fact, class them as agriculturally poor, but in my extended notes regarding the garden cultivation I remarked that it does not matter much whether the garden soil is naturally fertile or not, because the yield of the crops is mostly affected by the quality and quantity of manure given. As regards the soil it must be of such consistence that Needs of the soil.

PIPER nigrum.

Cultivation of Pepper in the Bombay Presidency

MANURIAL NEEDS OF PEPPER SOILS

it withstands the denuding effect of flood water and be so retentive of moisture that little or no irrigation is required in the fair season. All the samples submitted to Dr. Leather possessed these desirable qualities. It has already been shown that the leaves and twigs used by the cultivators are rich in potash and also in nitrogen, in which the soils are decidedly deficient. It has also been shown that the trampling of the leaves under cattle and the absorption of the excreta particularly, if the cattle are partially fed on cake, improves the resultant manure in phosphates. Dr. Leather has not separately estimated the amount of lime in the manures, but he shows that the soils are deficient in this important ingredient. I have already stated that the *matti* tree when burnt leaves an ash rich in lime, or, according to local opinion, it yields *chunam*. The cultivators are specially anxious to be allowed to take the leaves and twigs of this tree. If the manure applied to the trees in the Kánara gardens was mixed, as in common agricultural practice, freely with the soil, then the soil in old-established gardens would probably be richer in manurial ingredients than new soil.

Conclusion.

13 I conclude from a study of Dr. Leather's analysis that the system of manuring, as practised in the gardens of Kánara, is as right in theory and practice as it well can be, provided the manure as it accumulates in the pits is subjected in the least possible degree to the wasteful wash of the heavy Kánara rainfall.

P. 811-20.

G. I. C. P. O.—No. 733 R. & A.—18-6-1901.—2,230.—H. R.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place according to the letter and number shown at the bottom of each page

The objects of THE AGRICULTURAL LEDGER are :—

(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers;

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept;

(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products to officials or other persons interested therein;

(4) To secure a connection between all papers of interest published on subjects relating to economic products and the official Dictionary of Economic Products With this object the information published in these Ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.

To facilitate the preparation of an index to THE AGRICULTURAL LEDGER, the following arrangements have been made, commencing with 1900 :—

All papers published will be paged, irrespective of subjects, into an annual volume. The annual paging will be given on the top of the pages. But to permit of a continuation of the classification into the various series hitherto observed, a further folio will be shown at the bottom of the pages. This will be preserved throughout each series and be continued for several years, until in fact sufficient material in each series has been accumulated to constitute a fair sized volume

At the end of the year a printed index and title page will be issued, for the annual volume, and after a period of, say, five years an index and title page will be issued for each series. It has been found that many persons subscribe for a certain series only, and do not care to receive the others. The new arrangement, while permitting of the formation of an annual volume will at the same time retain the serial classification.

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[*Dictionary of Economic Products, Vol. VI., Pt. I.,* R. 67-70.]

THE NATURE, VALUE AND UTILISATION OF ALKALI LANDS.

E. W. HILGARD, ESQ., *Director of the Agricultural Experiment Station, ...ege of California, U. S. A. With a Prefatory Note and Appendix by* The Editor.

In October 1895, the Director, Royal Gardens, Kew, very kindly furnished the Reporter on Economic Products with a copy of a paper by Messrs. E. W. Hilgard and R H. Loughbridge on "The Distribution of the Salts in Alkali Soils" being Bulletin No. 108 of the Agricultural Experiment Station, University of California, published in August 1895. INTRODUCTORY.

That paper was, with the authority of the Government of India, reproduced in *The Agricultural Ledger*, No 1 of 1896.

The Board of Revenue, Madras, have now drawn attention to a fuller statement of the opinion of Professor E. W. Hilgard as published in Bulletin of the Agricultural Experiment Station of the University of California, No. 128, which was issued in 1900. The first 21 pages of the new Bulletin had, however, appeared in the Year-Book of the United States Department of Agriculture for 1895, and has thus very possibly been seen by most of the readers of *The Agricultural Ledger.*

At the suggestion of the Board of Revenue, Madras, it is, therefore, proposed to review here very briefly Professor Hilgard's revised paper on this subject so as to bring out the interesting additional particulars that have a possible bearing on the Indian problem of Reh efflorescence, in amplification of what has been already published in *The Agricultural Ledger*, No. 1 of 1896.

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DISTRIBUTION OF ALKALI LANDS IN THE WORLD.

ON THE DISTRIBUTION OF ALKALI LANDS (pp. 4-5).

"In looking over a rainfall map of the globe," says Professor Hilgard, "we see that a very considerable portion of the earth's surface has deficient rainfall, the latter term being commonly meant to imply any annual average less than 20 inches (500 millimetres). The arid region thus defined includes in North America, most of the country lying west of the one hundredth meridian up to the Cascade Mountains, and northward beyond the line of the United States; southward, it reaches far into Mexico, including especially the Mexican plateau. In South America it includes nearly all the Pacific Slope (Peru and Chile) south to Araucania; and eastward of the Andes, the greater portion of the plains of Western Brazil and Argentina In Europe only a small portion of the Mediterranean border is included; but the entire African coast-belt opposite, with the Saharan and Libyan deserts, Egypt and Arabia, are included therein as well as a considerable portion of South Africa. Asia Minor, Syria (with Palestine), Mesopotamia, Persia, and North-Western India up to the Ganges, and northwards, the great plains or steppes of Central Asia, eastward to Mongolia and Western China, fall into the same category; as does also a large portion of the Australian Continent.

"Over these vast areas alkali lands occur to a greater or less extent, the exceptions being the mountain regions and adjacent lands on the side exposed to prevailing oceanic winds. It will, therefore, be seen that the problem of the utilisation of alkali lands for agriculture is not of local interest only, but is of world-wide importance. It will also be noted that many of the countries referred to are those in which the most ancient civilisations have existed in the past, but which at present, with few exceptions, are occupied by semi-civilised people only It is doubtless from this cause that the nature of alkali lands has until now been so little understood that even their essential distinctness from the sea-border lands has been but lately recognised in full. Moreover, the great intrinsic fertility of these lands has been very little appreciated, their repellant aspect causing them to be generally considered as waste lands.

"This aspect is essentially due to their natural vegetation being in most cases confined to plants useless to man, commonly designated as 'saline vegetation' of which but little is usually relished by cattle.

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DISTRIBUTION OF ALKALI LANDS IN THE WORLD.

Notable exceptions to this rule occur in Australia and Africa, where the 'salt-bushes' of the former and the 'karroo' vegetation of the latter form valuable pasture grounds. Apart from these, however, the efforts to find for these lands, while in their natural condition, culture plants generally acceptable, or at least profitable, outside of forage crops, have not been very successful."

Professor Hilgard here illustrates by actual statistical returns and maps (very similar to those already given in *The Agricultural Ledger*, No. 1 of 1896, pages 4*a*, 4*b*, 4*c*), the following subjects, *viz.*, "How Plants are Injured by Alkali," "The Effects of Irrigation," "Determination of the Distribution of the Alkali Salts," and "Composition of Alkali Salts," and thereafter gives the following—

GENERAL CONCLUSIONS (*pp. 13-14*).

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"Summing up the conclusions from the foregoing observations and considerations we find that—

(1) "The amount of soluble salts in alkali soils is usually limited, they are not ordinarily supplied in indefinite quantities from the bottom water below These salts have essentially been formed by weathering in the soil layer itself.

(2) "The salts ordinarily move up and down within the upper 4 or 5 feet of the soil and sub-soil, following the movement of the moisture; descending in the rainy season to the limit of the annual moistening as a maximum and then re-ascending or not according as surface evaporation may demand. At the end of the dry season in untilled irrigated land, practically the entire mass of salts may be within 6 or 8 inches of the surface.

(3) "The injury to vegetation is caused mainly, sometimes wholly, within a few inches of the surface, by the corrosion of the bark, usually near the root crown This corrosion is strongest when carbonate of soda (salsoda) forms a large proportion of the salts, the soda then also dissolves the vegetable mould, and causes blackish spots in the soil, popularly known as black alkali.

(4) "The injury caused by carbonate of soda is aggravated by its action in puddling the soil so as to cause it to lose its

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GENERAL CONCLUSIONS.

flaky condition, rendering it almost or quite untillable. It also tends to form in the depths of the soil layer a tough hard pan, impervious to water, which yields to neither plough, pick, nor crowbar, and renders drainage and leaching impossible. Its presence is easily ascertained by means of a pointed steel-sounding rod.

(5) "While alkali lands share, with other soils of the arid region, the advantage of unusually high percentages of plant-food in the insoluble form, they also contain alongside of the noxious salts considerable amounts of water-soluble plant-food. When, therefore, the action of the noxious salts is done away with, they should be profusely and lastingly productive; particularly as they are always naturally somewhat moist in consequence of the attraction of moisture by the salts, and are, therefore, less liable to injury from drought than the same soils when free from alkali."

Professor Hilgard, in the pages that here follow in his revised paper up to page 22, deals with the "Utilisation and Reclamation of Alkali Lands," "Chemical Remedies," "Removal of Salt from the Soil" and with the answers to the question "Will it pay to Reclaim Alkali Lands." The Professor's views on these various topics have, for the present purpose, been sufficiently indicated by pages 2-7 of *The Agricultural Ledger*, No. 1 of 1896. But the final conclusion on the topic of whether or not it will pay to reclaim alkali lands may be here given, since it leads up very naturally to the subject of the crops suitable as agents of reclamation:—

Will reclaiming pay?

"It does not of course follow that alkali lands are good lands for farmers of limited means to settle upon. On the contrary, like most other business enterprises they require a certain amount of capital and lapse of time to render them productive. They are not, therefore, a proper investment for farmers or settlers of small means dependent on annual crops for their livelihood and unable to bring to bear upon these soils the proper means for their reclamation; unless indeed, local conditions should enable them to use successfully some of the crops specially adapted to alkali lands."

As explained above, the new material which Professor Hilgard has given to the public may be said to be his remarks on the crops

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suitable for alkali lands, namely, pages 22 to 46 of the new report. Many of the plants mentioned on these pages are either unknown to Indian cultivators or quite unsuited to Indian agriculture. Still the general contention would not be fully shown were these omitted.

GENERAL CONTENTION THE SAME IN INDIA AND IN NORTH AMERICA.

I propose accordingly to quote the Professor's remarks in full, omitting only the interesting plates which greatly enhance the value of the original. The cost of reproduction would, however, from the Indian standpoint greatly exceed their value. By way of emphasizing Professor Hilgard's observations, I shall then conclude by reviewing all the available Indian information on the wild or cultivated plants that have a reputation of being suitable for reclamation of reh efflorescent soils.

CROPS SUITABLE FOR ALKALI LANDS (pp. 22-46).

CROPS SUITABLE IN NORTH AMERICA.

"As has already been stated, the search for generally available crops that will thrive in strong unreclaimed alkali land has not thus far been very successful. It is true that cattle will nibble alkali grass (**Distichlis spicata**), but will soon leave it for any dry feed that may be within reach. The same is true of all the fleshy plants that grow on the stronger alkali lands and are known under the general designation of alkali weeds. When stock unaccustomed to it are forced by hunger to feed on such vegetation to any considerable extent, disordered digestion is apt to result; which in such ranges, however, is often counteracted by feeding on aromatic or astringent antidotes, such as the gray sage-brush, and the more or less resinous herbage of plants of the sunflower family. In the Great Basin region lying between the Sierra Nevada and the front range of the Rocky Mountains, there are, aside from the grasses, numerous herbaceous and shrubby plants that afford valuable pasturage for stock, and some of these grow on moderately strong alkali land; the same is true in California. It is quite possible that some of these will be found to lend themselves to ready propagation for culture purposes as well as they do for re-stocking the ranges. But thus far none have found wider acceptance, probably because their stiff branches and upright habit render them inconvenient to handle. It will require more extended experience and experiment before any of these can be definitely adopted by farmers.

"Experience in California indicates that in the more southerly portion of the arid region the unpalatable native plants may ... B ...ately

Unlike the salt-bushes it is, therefore, a formidable weed is not wanted; but as, according to our determinations, it much as 52,000 pounds of salts per acre, even when 41,000 is common salt, it is likely to be useful in many cases, parti. as an admixture to a salt-bush diet for stock, the more as it not absorb as much salt as the latter. Owing to the rooting of the stems, it is not as convenient to handle as the semi-ita salt-bush, nor, probably, will it yield as much fodder in a n. It seems best adapted to pasturage. CROPS SUITABLE IN NORTH AMERICA.

Another forage plant which it may hereafter pay to propagate icially on strong alkali land is the tussock-grass (Sporobolus roides). Indicating as it usually does when growing naturally, nd too strongly impregnated to be reclaimable at this time, but being eaten freely by stock, it seems worth while to count it among the possible pasture grasses for land too strongly alkaline to bear ordinary crops. Its seed can be abundantly gathered in its native habitats indicated below.

AMOUNT OF SALTS COMPATIBLE WITH ORDINARY CROPS.

Since the amount of alkali that reaches the surface layer is largely dependent upon the varying conditions of rainfall or irrigation and surface evaporation, it is difficult to foresee to what extent that accumulation may go, unless we know the total amount of salts present that may be called into action. This can be ascertained by a summation of the results obtained, but more readily by the examination of one sample representing the average of the entire soil column of 4 feet. By calculating the figures so obtained to an acre of ground, we can at least approximate the limits within or beyond which crops will succeed or perish. LIMIT OF SALINITY FOR VARIOUS CROPS.

Grasses.—Applying this procedure to the cases investigated at the Tulare sub-station, and estimating the weight of the soil per acre-foot at 4,000,000 pounds, we find for the land on which *barley* refused to grow the figures 32,480 pounds of total salts per acre, corresponding to 0·203 per cent.; while for the land on which barley gave a full crop we find 25,440 pounds, equivalent to 0·159 per cent. for the whole soil column of 4 feet. It thus appears that for barley the of tolerance lie between the above two figures, which might, of have been obtained equally well from an average sample of ...ately Grain crops.

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CROPS SUITABLE IN NORTH AMERICA.

generally replaced, even on the ranges, by one or more species of the Australian salt bushes (**Atriplex** spp.), long ago recommended by Baron von Mueller of Melbourne; of which one (**A. semibaccata**) has proved eminently adapted to the climate and soil of California and is readily eaten by all kinds of stock. The facility with which it is propagated, its quick development, the large amount of feed yielded on a given area, even in the strongest alkali land ordinarily found, and its thin flexible stems, permitting it to be handled very much like alfalfa (**Medicago sativa**), seem to commend it specially to the farmer's consideration wherever the climate will permit of its use *Its resistance to severe cold weather has not yet been adequately tested.* It is probable that other species, now also under trial, will equally justify the recommendation given them by the eminent botanist who first brought them into public notice as promising forage plants. Most of the species have an upright, shrubby habit, which adapts them rather to browsing than to use as a forage crop. Among the best, next to the **semibaccata**, are the species **leptocarpa** and **halimoides**, the former somewhat similar in habit to the **semibaccata**, but not so rapid a grower."

"It is to be noted that since the salt-bushes take up nearly one-fifth of their dry weight of ash ingredients, largely common salt, the complete removal from the land of a five-ton crop of salt-bush hay will take away nearly a ton of the Alkali salts per acre. (Analyses made at the California Station show 19·37 per cent. of ash in the air-dry matter of Australian salt-bush. Analyses of Russian thistle (**Salsola Kali** *var.* **Tragus**) have been reported showing over 20 per cent. of ash in dry matter). This will in the course of some years be quite sufficient to reduce materially the saline contents of the land, and, will frequently render possible the culture of ordinary crops.

"Next to the salt-bushes the Chilian plant **Modiola decumbens** (now commonly known as 'modiola' simply), of the mallow family, deserves attention Accidentally introduced as a weed with other seeds, by the Keror County Land Company at Bakersfield, it attracted attention by its persistence on alkali lands, and by the observation that cattle ate it freely. It was then grown on a larger scale, and found to make acceptable pasture where alfalfa could not be grown on account of alkali. *It is a trailing* plant with medium-sized round-r. foliage, and roots freely at the joints where they touch the

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LIMIT OF SALINITY FOR VARIOUS CROPS.

of these. It must be remembered that in more loose-textured sandy lands than those in which these tests were made, the above figures for tolerance would probably be increased by 30 per cent. or more.

"Doubtless some of the indigenous grasses of the interior plateau region and the great plains east of the Rocky Mountains, such as the buffalo and grama grasses, as well as several of the wheat grasses (Agropyron) and bunch grasses (Festuca, Poa, Stipa, etc.) will prove resistant to larger proportions of alkali than the meadow and pasture grasses of the regions of summer rains

"*Legumes.*—Both the natural growth of alkali lands and experimental tests seem to show that this entire family (peas, beans, clovers, etc.) are among the more sensitive and least available wherever black alkali exists, while fairly tolerant of the white (neutral) salts. Apparently a very little salsoda suffices to destroy the tubercle-forming organisms that are so important a medium of nitrogen-nutrition in these plants, alfalfa, with its hard, stout and long tap root, seems to resist best of all these plants excepting the melilots As a general thing, tap-rooted plants, when once established, resist best, for the obvious reason that the main mass of their feeding roots reaches below the danger level. Another favouring condition, already alluded to, is heavy foliage and consequent shading of the ground; alfalfa happens to combine both of these advantages. There has been some difficulty in obtaining a full stand of alfalfa in the portion of the Chino tract containing from 4,000 to 6,000 pounds of alkali salts per acre, but once obtained it has done very well. The only other plant of this family that succeeds well on this land and even (at Tulare) on soil considerably stronger (probably between 20,000 and 30,000 pounds) are the two melilots, Melilotus indica and alba; the latter (the Bokhara clover) is a forage plant of no mean value in moist climates, but somewhat restricted in its use in California because of the very high aroma it developes, especially in alkali lands, so that stock will eat only limited amounts, except when intermixed with other forage, such as the salt-bushes. The yellow melilot is highly recommended by the Arizona station as a green manure plant for winter growth; but in this state it is a summer-growing plant only, and is refused by stock. Very few plants belonging to this family are naturally found on alkali lands, and attempts to grow them, even where only glauber salt is present, have been but very moderately

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LIMIT OF SALINITY FOR VARIOUS CROPS

the 4-foot column by making a single analysis. It should be noted that in this case a full crop of barley was grown even when the alkali consisted of fully one half of the noxious carbonate of soda, proving that it is not necessary in every case to neutralise the *entire* amount of that salt by means of gypsum, which in the present case would have required about 9½ tons of gypsum per acre—a prohibitory expenditure.

"Rye appears to be about like barley in its tolerance of alkali salts; while wheat is somewhat more sensitive. In fact the superficial rooting and fine fibrous roots of the true grasses render them, as a whole, rather sensitive to alkali salts, yet there are a number of the perennial kinds whose thick roots and deeper rooting render them measurably resistant. Aside from the alkali grass proper (Distichlis), the so-called rye-grass of the North-West (Elymus condensatus) is probably, next to the tussock-grass, the most resistant species among the wild grasses. Its southern form, with several others not positively identified, occupy largely the milder alkali lands of Southern California, such as the low lands near Chino, producing choice sugar beets on a close-textured silty loam.

"While maize is rather sensitive, and fails on even slightly alkaline lands, Egyptian corn and other sorghums, rooting somewhat deeper, and having stout roots do well on mild alkali soils of the white class. The same appears to be true of some of the stout-rooted millets, such as barnyard grass (Panicum Crus-galli), of which the variety (?) muticum is reported to succeed in neutral alkali land. One of the most successful grasses on the light alkali lands near Chino, where most of the commonly cultivated kinds fail, was a near relative of the barnyard grass, the Eleusine Coracana, which produces heavy crops of a millet-like grain much relished by poultry and also by stock. This grass has succeeded all over the ground whose alkali content ranges up to 12,000 pounds per acre. Next to this, in point of success, were the pearl millet (Pennisetum typhoideum) and teosinte, Hungarian brome grass, and Japanese millet, on land containing about 9,000 pounds of salts per acre. The loliums, including the darnel ('California cheat' Lolium temulentum) and the *Australian and Italian ray ('rye') grasses* Lolium perenne, *succeed* fairly on land containing as much as 6,000 pounds of (white) salts. Most other cultivated grasses failed conspicuously alongside

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of these. It must be remembered that in more loose-textured sandy lands than those in which these tests were made, the above figures for tolerance would probably be increased by 30 per cent. or more.

"Doubtless some of the indigenous grasses of the interior plateau region and the great plains east of the Rocky Mountains, such as the buffalo and grama grasses, as well as several of the wheat grasses (Agropyron) and bunch grasses (Festuca, Poa, Stipa, etc) will prove resistant to larger proportions of alkali than the meadow and pasture grasses of the regions of summer rains.

"*Legumes.*—Both the natural growth of alkali lands and experiental tests seem to show that this entire family (peas, beans, clovers,) are among the more sensitive and least available wherever k alkali exists, while fairly tolerant of the white (neutral) salts. ently a very little salsoda suffices to destroy the tubercle-g organisms that are so important a medium of nitrogen-nutri- in these plants, alfalfa, with its hard, stout and long tap root, seems to resist best of all these plants excepting the melilots As a general thing, tap-rooted plants, when once established, resist best, for the obvious reason that the main mass of their feeding roots reaches below the danger level. Another favouring condition, already alluded to, is heavy foliage and consequent shading of the ground; alfalfa happens to combine both of these advantages. There has been some difficulty in obtaining a full stand of alfalfa in the portion of the Chino tract containing from 4,000 to 6,000 pounds of alkali salts per acre, but once obtained it has done very well. The only other plant of this family that succeeds well on this land and even (at *l u'are) on soil considerably stronger (probably between 20.000* and 30,000 pounds) are the two melilots, Melilotus indica and alba; the latter (the Bokhara clover) is a forage plant of no mean value in moist climates, but somewhat restricted in its use in California because of the very high aroma it developes, especially in alkali lands, so that stock will eat only limited amounts, except when intermixed with other forage, such as the salt-bushes The yellow melilot is highly recommended by the Arizona station as a green manure plant for winter growth; but in this state it is a summer-growing plant only, and is refused by stock. Very few plants belonging to this family are naturally found on alkali lands, and attempts to grow them, even where only glauber salt is present, have been but very moderately

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successful. The salts seem to retard or even prevent the formation of the tubercles useful for nitrogen absorption: and for most of the legumes the limit of full success seems to lie between 3,000 and 4,000 pounds to the acre.

Miscellaneous plants

"*Weeds.*—Like the legumes, wild plants of the mustard family are rare on alkali lands; and correspondingly, the cultivated mustard, kale, rape, etc., fail even *on land quite weak in alkali. Their limit* of tolerance seems to lie near 4,000 to 5,000 pounds per acre of even white salts.

"Several of the hardiest of the native 'alkali weeds' belong to the sunflower family, and the common wild sunflowers (**Helianthus californicus** and **H. annuus**) are common on lands pretty strongly alkaline. Correspondingly, the 'Jerusalem artichoke,' itself a sunflower, is among the available crops on moderately strong alkali soils; and so, doubtless, are other members of the same relationship not yet tested, such as the true artichoke, salsify, etc. Chicory, belonging to the same family, yielded roots at the rate of 12 tons per acre on land on the Chino tract containing about 8,000 pounds of salts per acre.

Root crops.

"*Root Crops.*—It seems to be generally true that root crops suffer in quality, however satisfactory may be the quantity harvested on lands rich in salts, and especially in chloride (common salt) It was noted at the Tulare sub-station that the tubers of the artichoke were inclined to be 'squashy' in the stronger alkali land, and failed to keep well; the same was true of potatoes, which were very watery; and also of turnips and carrots. It is a fact well known in Europe, that potatoes manured with kainit (chlorides of potassium and sodium) are unfit for the manufacture of starch, and are generally of inferior quality But this is found not to be the case when, instead of the chloride, the sulphate is used; hence the advice often repeated by this station, that farmers desiring to use potash fertilisers should call for the 'high-grade sulphate' instead of the cheaper kainit, which adds to the injurious salts already so commonly present in California lowland soils

"The common beet (including the mangel-wurzel) is known to succeed well on saline seashore lands, and it maintains its reputation on alkali lands also. Being specially tolerant of common salt it may be grown where other crops fail on this account; but the roots so

grown are strongly charged with common salt, and have, as is well known, been used for the purpose of removing excess of the same from marsh lands. Such roots are wholly unfit for sugar-making. LIMIT OF SALINITY FOR VARIOUS CROPS.

"It is quite otherwise with glauber salt (sodium sulphate); and as this is usually predominant in alkali lands, either before or after the gypsum treatment, this fact is of great importance, for it permits of the successful growing of the sugar beet, as has been abundantly proved at the Chino ranch, where land containing as much as 12,000 pounds of salts, mostly this compound, has yielded roots of very high grade both as to sugar percentage and purity.

"Asparagus is another crop which bears considerable amounts of common salt as well as glauber salt, but not of salsoda, which must first be transformed by the use of gypsum. Vegetable crops.

"Rhubarb was a conspicuous failure in even the weak alkali lands of the Chino tract.

"*Textile Plants.*—Japanese hemp seemed to have a hard struggle with the alkali while young, but at the end of the season stood 8 feet high. The ramie plant, also, will bear moderately strong alkali, apparently somewhat over 12,000 pounds per acre. Flax has not been tested in cultivation; but its wide distribution all over the States of Oregon and Washington would seem to indicate that it is not very sensitive. Another textile plant, the Indian mallow (Abutilon avicennæ) was found to fail on the Chino alkali soil. Textile plants.

"*Grapevines.*—Vitis vinifera is quite tolerant of white or neutral alkali salts, and will resist even a moderate amount of the black so long as no hardpan is allowed to form. At the Tulare sub-station, it was found that grapevines did well in sandy land containing 35,230 pounds of alkali salts, of which one half was glauber salt, 9,640 pounds carbonate of soda, 7,550 pounds common salt, and 750 pounds nitrate of soda. They were badly distressed where, of a total of 37,020 pounds of alkali salts, 25,620 pounds was carbonate of soda; while, where the vines had died out, there was found a total of 73,930 pounds, with 37,280 pounds of carbonate. The European vine, then, is considerably more resistant of alkali even in its worst (black) form, than barley and rye; and it seems likely that the native grapevines of the Pacific Coast, Californica and Arizonica, would resist even better; a point still under experiment. Grapes.

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"Experience, however, has shown that vines rapidly succumb when by excessive irrigation the bottom water is allowed to rise, increasing the amount of alkali salts near the surface and shallowing the soil at their disposal. Such over-irrigation has been a fruitful cause of injury to vineyards in the Fresno region, and would doubtless, if practised, kill most of the vines at Tulare sub-station which are now flourishing. In such cases sometimes the formation of hardpan is followed by that of a concentrated alkaline solution above it, strong enough to corrode the roots themselves, and not only killing the vines, but rendering the land unfit for any agricultural use whatsoever. The swamping of alkali lands, whether of the black or white kind is not only fatal to their present productiveness, but, on account of the strong chemical action thus induced, greatly jeopardises their future usefulness. Many costly investments in orchards and vineyards have thus been rendered unproductive, or have even become a total loss.

Oranges, etc.

"*Citrus Trees.* - These are *on the whole* rather sensitive to alkali, especially while young; so that it is often difficult to obtain a stand even when later on, the feeding roots descend beyond the reach of injury. In the close-textured lands of Chino, young trees hardly maintained life with more than 5,000 pounds of total salts. Common salt seems to be particularly injurious; near Riverside, full-grown trees perished under the influence of bottom water containing 0·25 per cent. or 146 grains of salt per gallon, which impregnated the ground; corresponding to about 9,000 pounds per acre in four feet."

"In the sandy loam lands near Corona, trees eight years old suffered severely when by irrigation with alkali water the alkali content of the land reached 11,000 pounds per acre; at another point in the same region, two representative trees were selected for comparison, five rows apart on land absolutely identical; one of these retained its leaves, though suffering, the other was completely leafless. The leaching of the alkali to the depth of 4 feet gave the following results, calculated to pounds per acre

	Sulphates.	Carbonates.	Chlorides.	TOTAL.
Poor tree .	4,720	1,680	2,520	8,920
Better tree .	4,120	2,360	720	7,200

"Here it is apparently the excess of common salt to which the difference is due, and this despite the higher content of carbonate of soda in the soil bearing the better tree.

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of Alkali Lands. (*E W. Hilgard*) | REH.

LIMIT OF SALINITY FOR VARIOUS CROPS.

"On the other hand, at the Tulare sub-station, orange trees (*sour stock*) maintain vigorous growth and good bearing in a very sandy tract which to the depth of 7 feet showed an aggregate content of 26,840 pounds of salts (or 22,780 to 4 feet depth); but which is never irrigated. The salts in this case consist wholly of *sulphate* and *carbonate of soda* in the ratio of 54 to 42, implying the presence of nearly 12,000 pounds of salsoda within reach of the tree-roots; yet in the absence of common salt, no perceptible injury or even stress upon the trees has been noted.

"In view of these facts, it seems that common salt is the portion of alkali by far most injurious to citrus trees, and great care should be taken in the use of irrigation waters to exclude those charged with common salt, also to avoid locating citrus orchards where common salt pre-exists in the land

Orchard trees.

"*Deciduous Orchard Trees.*—Of these, strangely enough, the almond seems to resist best. The peach is more sensitive, the apricot does fairly. Plum trees as such are nearly as resistant as peaches, but sometimes suddenly begin to fail when beginning to bear; the fruit appears normal on the outside for a time, but the pit fails to form, being sometimes flattened out like a piece of pasteboard; and the fruit fails to mature. Apples are rather sensitive; pears considerably less so, doing well even when the outside bark around the root crown is blackened by the alkali. The olive is quite resistant; the fig less so. The English walnut resents even a slight taint of black alkali, but is fairly tolerant of 'white' salts, as is shown in the peculiarly suitable light loam soils on the lower Santa Clara River in Ventura County.

"Figures for the limits of alkali tolerance in the case of the deciduous orchard trees have not yet been closely determined, owing to the difficulties inherent in the differences of root penetration in the several soils and localities On the ten-acre tract near Chino, therefore, on a rather close-textured soil, apple trees have done very well on land containing one-fourth of one per cent. of 'white' salts, or between 10,000 and 11,000 pounds per acre.

Trees.

"*Timber and Shade Trees.*—Of trees suitable for alkali lands, two native ones call for mention. One is the California white or valley oak (Quercus lobata), which forms a dense forest of large trees on the delta lands of the Kaweah River in California, and is found scatteringly all over the San Joaquin Valley,

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Unfortunately this tree does not supply timber valuable for aught but firewood or fence posts, being quite brittle. The native *cotton woods*, while somewhat retarded and dwarfed in their growth in strong alkali, are quite tolerant of the white salts, especially of glauber salt.

"Of other trees, **Platanus orientalis**, the oriental plane or sycamore, and the black locust, have proved the most resistant in the alkali lands of the San Joaquin Valley, and the former being a very desirable shade tree, it should be widely used throughout the regions where alkali prevails more or less The ailantus is about equally resistant, and but for the evil odour of its flowers, deserves strong commendation. Of the eucalypts, the narrow-leaved **Eucalyptus amygdalina** (one of the 'red gums') seems to be least sensitive, and in some cases has grown as rapidly as anywhere. **E. rostrata**, as well as the pink-flowered variety of **E. sideroxylon** are now doing about as well as the **amygdalina** at Tulare where at first they seemed to suffer. The common blue gum, **E. globulus**, is much more sensitive.

"Of the acacias the tall-growing **A. melanoxylon** ('black acacia') resists pretty strong alkali, even on stiff soil; as can be seen at Tulare and Bakersfield. where there are trees nearly two feet in diameter. The beautiful A. **lophantha (Albizzia)** has in plantings made along the San Joaquin Valley Railroad shown considerable resistance likewise; but it is quite sensitive to frost.

"One of the 'Australian pines,' **Casuarina equisetifolia**, was transplanted experimentally on station grounds of the Valley Railroad from the Chico forestry sub-station, and a number are growing very well in alkali lands. This tree is credited by Maiden with being tolerant of 'saline soil.' Doubtless many others of the **Casuarina** tribe will be found similarly resistant.

"Of Eastern trees, the elms have done fairly well, but the tulip tree, the linden, the English oak, and most other trees of the Atlantic States, became stunted Among those doing fairly well is the honey locust, but its thorns and imperfect shade render it not very desirable.

"The California maple (**Acer macrophyllum**) and box elder (**Negundo californica**) have done fairly well in the lighter alkali lands at Tulare.

"A most remarkably alkali-resistant shrub or small tree is the pretty **Koelreuteria paniculata**, which at Tulare is growing in some of the strongest alkali soil of the tract. Unfortunately it is

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available mainly for ornamental purposes; its wood, while small, is very hard and makes excellent fuel.

IRRIGATION WITH SALINE WATERS.

IRRIGATION WITH SALINE WATERS.

"It would hardly seem necessary to emphasize specially the danger incurred in irrigation with waters containing unusual amounts of soluble salts; since ordinary common sense clearly indicates the impropriety of increasing the saline contents of soils already charged with them, by the evaporation, year after year, of large masses of saline water. Yet experience has shown that the eagerness to utilise for irrigation whatever water happens to be convenient to good lands often overcomes both that sense and the warning given by the published analyses of such waters. Without specifying localities, it may be said that great injury has already been done in California by the disregard of obviously needful caution in this respect. The very slight taste possessed by glauber salt and salsoda does not adequately indicate their presence even when in injurious amounts; so that frequently a chemical test of the waters is the only definite guide. A few general rules, however, will help to enable the irrigator to determine whether or not such examination is called for. Great injury may be done.

"It may be taken for granted that *the waters of all lakes having no regular outflow are unfit for regular irrigation use*; since they must needs contain all the accumulations of salts from the secular evaporation of the waters that flow into them.

"The plates annexed* exhibit the cultural results of several years' irrigation with the waters of Lake Elsinore, Riverside County, as compared with the growth of orange trees on the same land, but irrigated with artesian water. Lake Elsinore is fed by the San Jacinto River and in wet years sometimes overflows for a few weeks into Temescal Creek. Thus its saline content varies somewhat, from about 80 to over 100 grains per gallon, of salts containing three-fifths of common salt and one-fifth each of glauber salt and carbonate of soda. The latter, as already stated, tends to form a hardpan in the sub-soil, and such hardpan was actually formed where the water was used; and afterwards prevented its proper penetration, so that the trees suffered from dryness of their lower roots, while damaged by the alkali salts near the surface. As mentioned before, experience elsewhere has shown that citrus trees are especially sensitive to common salt.

* Not reproduced.

REH.	The Nature, Value and Utilisation

SOURCES OF GOOD WATER FOR IRRIGATION IN *CALIFORNIA.*

"The investigations made by the Station have, moreover, shown that aside from the frequently saline character of the well and even the artesian waters of the petroleum-bearing region of the State in the coast ranges, the streams of that region, especially the smaller ones, are sometimes too strongly charged with 'alkali' (in this case largely the sulphates of soda and magnesia) to be suitable either for irrigation or domestic use. Toward the end of the dry season, even the larger streams of the Southern coast ranges, with their diminished flow, sometimes show an excess of salts. This seems also to be true of the San Jacinto River which feeds Elsinore Lake.

"The waters flowing from the Sierra Madre, south of the Tehachapi range, are throughout of excellent quality for irrigation purposes; as are all those flowing from the Sierra Nevada. The same is true of the artesian waters of the valley of Southern California, from Los Angeles east to Redlands, and of all the deeper borings of the Antelope Valley

"In the Great Valley, the artesian waters vary greatly in quality. Those of Kern and Tulare counties are mostly good, sometimes exceptionally so, as in the case of the water-supply of Tulare city. It is only the shallower borings, near the borders of Tulare Lake, that some waters strongly charged with carbonate of soda or other salts have been found From Fresno and Merced we have few data as yet, but it seems that north of a line drawn from North-Eastern Stanislaus *via* Tracy to Point of Timber, saline waters, sometimes accompanied by some gas, occur at certain levels. But the deep wells bored at Stockton and Sacramento, and northward, have good potable water.

WHEN A WATER-SUPPLY IS TOO SALINE FOR USE.

"*Limits of Saline Contents.*—Unfortunately it is not easy to give absolute rules in regard to the exact figures that constitute an excess of salts for irrigation purposes, since not only the composition of the salts, but also the nature of the land to be irrigated, and the frequency of irrigation required, must be taken into consideration.

"Broadly speaking, the extreme limits of mineral content usually assigned for potable waters, *viz.*, 40 grains per gallon, also applies to irrigation waters. Yet it sometimes happens that all or most of the solid content is gypsum and epsom salt; when only a large excess of the latter would constitute a bar to irrigation use. When, on the contrary, a large proportion of the solids consists of carbonate of soda or of common salt, even a smaller proportion of salts than

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40 grains might preclude its *regular* use, depending upon the nature of the soil to be irrigated. For, in a clay loam, or a heavy adobe not only do the salts accumulate nearer to the surface, but the sub-drainage being slow and imperfect (unless under-drained), it becomes difficult or impossible to wash out the saline accumulations from time to time as is feasible in sandy lands. In these, moreover, as already stated, the alkali never becomes as concentrated near the surface as in heavier soils Again where *hardpan* exists in sandy land saline irrigation-water soon saturates the soil mass above it with salts. During the two dry seasons just past saline waters have frequently been used, exceptionally, in order to save trees threatened with death from drought. The Station has even advised that this should be done, with the proviso that *the salts so introduced must be washed into the sub-drainage by heavy irrigation*, whenever practicable, even if the same saline water should have to be used for the purpose. For few such waters are sufficiently strong to injure vegetation *until concentrated by evaporation;* as can be seen from the vegetation growing close to the margins of alkaline lakes, with its roots immersed in the water. WHEN A WATER-SUPPLY IS TOO SALINE FOR USE.

The irrigator can determine for himself whether or not his water-supply is of doubtful character, by evaporating a tablespoonful, or more, in a clean silver spoon (avoiding boiling). If the dry residue should form simply a thin, powdery-looking film on the polished metal he may be assured that the water is all right. If, on the other hand, an obvious saline crust should remain, which will redissolve, in water, he should either have an analysis made, or use the water in such a manner as to remove the accumulated salts from time to time by washing them into the sub-drainage, if the nature of the soil permits. *A very abundant use of such waters is then preferable to a sparing one;* but the user should *assure himself that it really penetrates*, for otherwise, especially in case much carbonate of soda is present, a dense hardpan may be formed that will allow the trees to perish from drought despite all the water running in the irrigation furrows. A pointed steel probe, three-sixteenths of an inch square, provided with a cross handle, like a hand auger, ought to be among the tools of every farmer for such tests of his sub-soil. No farmer in the arid region can afford to be ignorant of the nature of the substrata within which the bulk of the roots of his crops must vegetate. Occasions when one may be forced to use saline waters.

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TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

RECLAIMABLE AND IRRECLAIMABLE ALKALI LANDS AS DISTINGUISHED BY THEIR NATURAL VEGETATION.

"While, as shown above, the adaptation or non-adaptation of particular alkali lands to certain cultures may be determined by sampling the soil and subjecting the leachings to chemical analysis, it is obviously desirable that some other means, if possible, available to the farmer himself should be found to determine the reclaimability and adaptation of such lands for general or special cultures.

"The natural plant growth seems to afford such means, both as regards the quality and quantity of the saline ingredients. The most superficial observation shows that certain plants indicate extremely strong alkali lands where they occupy the ground alone; others indicate pre-eminently the presence of common salt; the presence or absence of still others form definite or probable indications of reclaimability or non-reclaimability Many such characteristic plants are well known to and readily recognised by the farmers of the alkali districts. 'Alkali weeds' are commonly talked about almost everywhere; but the meaning of this term — *i.e.*, the kind of plant designated thereby—varies materially from place to place according to climate as well as to the quantity of the soil. Yet if these characteristic plants could be definitely observed, described and named, while also ascertaining the amount and kind of alkali they indicate as existing in the land, lists could be formed for the several districts, which would indicate, in a manner intelligible to the farmer himself, the kind and degree of impregnation with which he would have to deal in the reclamation work, thus enabling him to go to work on the basis of his own judgment, without previous reference to this Station.

"The carrying out of such a plan involves, obviously, a very large amount of botanical as well as chemical work, which cannot be accomplished within a few seasons, and in view of the wide difference in the vegetation of the several alkali regions of the State the same work will have to be repeated to a certain extent in each of these regions. The object to be achieved is, however, of such high practical importance—an importance not remotely appreciated as yet by those not familiar with the enormous extent of otherwise desirable lands in this State that are more or less tainted with alkali—as to deserve the expenditure upon it of a large amount of work as promptly as possible.

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TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

"The extreme limitation of funds under which the Agricultural College, together with the University as a whole, has been suffering for some years past, has thus far restricted the scope of researches very closely both geographically and otherwise. It is hoped that in the future, a close comparison of the native vegetation with the chemical determination of the quantity and kind of alkali corresponding to certain plants, or groups of plants, naturally occurring on the land, may enable us to come to a sufficiently close estimate of the nature and capabilities of the latter from the native vegetation alone, or with the aid of test plants purposely grown. But before entering upon this complex problem, it has been thought best to determine, first of all, what lands may for present economic conditions be considered *irreclaimable* because their improvement would involve an expense out of proportion with present land values So far as large areas are concerned, this may probably be considered to be the case when tile under drainage is required in order to wash out the salts; while of course smaller tracts, which interrupt the cultivation of fields, may frequently justify the laying of a few drain lines required to render them cultivable with the rest of the land.

"As stated in the report of this Station for 1895-97, the field work of this investigation, both botanical and in the collection of the corresponding soil samples, has been done by Mr. Joseph Burtt Davy, Assistant Botanist to the Station, who also supplies the notes accompanying the same; while the laboratory work for the determination of the amounts and kinds of salts present in the several cases has been carried out by Professor R. H. Loughridge

"The plants hereinafter mentioned are then to be understood as indicating, *whenever they occupy the ground as an abundant and luxuriant growth* that such land is irreclaimable for ordinary crops, unless underdrained for the purpose of washing out surplus salts. The occurrence merely of scattered, more or less stunted individuals of these plants, while a sure indication of the presence of alkali salts does not necessarily show that the land is irreclaimable.

"The plants which may best serve as such indicators in California are the following :— Californian Indicators.

Tussock-grass (Sporobolus airoides, *Torr*).

Greasewood (Sarcobatus vermiculatus, *Torr*).

Dwarf Samphire (Salicornia subterminalis, *Parish*, and other species).

TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION

Bushy Samphire (**Allenrolfea occidentalis**, *O. Ktze.*, better known as **Halostachys occidentalis**, *S. Wats.*).

Salt-wort (**Suaeda torreyana**, *S. Wats.*, and **S. suffrutescens**, *S. Wats.*).

Alkali-heath (**Frankenia grandifolia** *var.* **campestris**, *A. Gray*).

Cressa (**Cressa cretica** *var.* **truxillensis**, *Choisy*).

Tussock-grass—so called because it grows in large clumps or tussocks (**Sporobolus airoides**, *Torr*).

Sporobolus airoides.

"The three sets of samples of Tussock-grass soil which have been analysed show that the total amount of all salts present is in no case less than 49,000 pounds per acre, to a depth of four feet, and that it sometimes reaches the extraordinarily high figure of 499,000 pounds. Of these amounts the neutral salts (glauber salt and common salt) are usually in the heaviest proportion (glauber salt, 19,600 to 323,000 pounds per acre; common salt, 3,500 to 172,800), the corrosive salsoda varying from 3,000 to 44,000 pounds. Tussock-grass apparently cannot persist in ground which is periodically flooded. This fact is of special importance because it is an acceptable forage for stock.

"Tussock-grass is a prevalent alkali-indicator in the hot arid portions of the interior, from the Upper San Joaquin Valley, the Mojave Desert, and southward; also through Southern Nevada and Utah as far east as Kansas and Nebraska. In the San Joaquin Valley we have not found it further north than the Tulare plains, although East of the Sierra it occurs near Reno. Coville observes that in the Death Valley region 'it is confined principally to altitudes below 1,000 metres' (3,280 feet). Hillman, however, reports it from near Reno, Nevada, at an altitude which cannot be much less than 4,500 feet.

"As we have received requests for precise information as to the localities in which this grass grows, from persons desiring to obtain seed for trial, the following list is given: Tulare plains a few miles south-east of Tulare; a few miles south of Bakersfield; in the Antelope Valley; along the road from Rosamond to Lancaster, and in alkali sinks about the Leonis Valley between Lancaster and Elizabeth Lake. It is reported by Coville from Death Valley, Pahrump

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Valley, Resting-Springs Valley, Owens River Valley, and other points in the desert region south-east of the Sierra Nevada. It is also recorded from near Barstow and other points in San Bernardino *County; in dry soils near Los Angeles and from San Diego County.* TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

"***Greasewood (the true Greasewood of the desert region east of the Sierra Nevada, and not either of the plants known under that name in the San Joaquin Valley and in Southern California,*** Sarcobatus vermiculatus, *Torr.*).

"Through the courteous co-operation of Professor F. H. Hillman, Botanist to the Nevada Agricultural Experiment Station at Reno, we have obtained three series of samples of Greasewood soil from that vicinity. These samples show that where the Greasewood shrubs are thinly scattered and stunted in growth, the salt content per acre to the depth of three feet is about 2,400 pounds, of which over one half consists of the corrosive carbonates. Where a luxuriant growth occurs the total salts per acre vary from 38,000 to 58,500 pounds, with 18,700 pounds of salsoda and 920 to 3,680 pounds of common salt; the relative percentage of the injurious salsoda is thus invariably high. The common salt is low and the neutral glauber salt is variable. This plant, therefore, always indicates the presence of 'black alkali.' Sarcobatus vermiculatus.

"Greasewood is distinctly a plant of the Great Basin, only reaching California in the adjacent counties of Lassen, Alpine, Mono and Northern Inyo. It is very abundant on the lower levels of Honey Lake Valley.

"***Dwarf Samphire*** (Salicornia subterminalis, *Parish*, ***and other species of the interior***).

"The two or three species of Dwarf Samphire which grow in the interior valleys of the State are nowhere very abundant in those portions of the alkali region which we have thus far investigated. Wherever the species do occur, however, they are confined to such very strongly saline soils that they may be considered valuable indicative plants. We have as yet only one full set of samples of Dwarf Samphire soil. This shows the total salt content to amount to 441,880 pounds per acre in a depth of four feet. The neutral glauber salt amounts to 314,000 pounds, almost as much as in Tussock-grass soil; common salt up to 125,640 pounds, while the Salicornia subterminalis.

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salsoda varies from 2,200 to 12,000. We may consider this plant as indicative of almost the highest percentage of common salt, glauber salt and total salts. Like the preceding species, it indicates 'white' salts in excessive amounts, and a sub-soil too wet for the Australian salt-bush. Salicornia subterminalis occurs in San Diego, Riverside, Los Angeles, and Kern Counties. S. herbacea, *L.*, is reported from Riverside County, and from the margin of Tehachapi Lake, Kern County. S. mucronata, *Bigelow*, occurs in San Diego County, and a fourth species is found in the Antelope Valley, Los Angeles County; near Bakersfield, Kern County; and at Byron Springs, Contra Costa County. These inland species all differ materially in habit and botanical characters from the one common in submerged salt marshes along the seashore, but all alike indicate strongly saline soils.

"*Bushy Samphire* (Allenrolfea occidentalis. *O. Ktze*, better known as Haloschys occidentalis, *S. Wats.*).

Halostachys occidentalis.

"This plant is locally called greasewood, but as this name is much more commonly used for Sarcobatus vermiculatus, it seems best to call it 'bushy samphire,' as it closely resembles the true samphire (Salicornia)

"Bushy samphire usually grows in low sinks, in soil which in winter is excessively wet and in summer becomes a 'dry bog.' Whenever the plant grows luxuriantly the salt content is invariably high, the total salts varying from 327,000 per acre, to a depth of three feet to 494,520 pounds in four feet. The salts consist mainly of glauber and common salts (a maximum of about 275,000 pounds of each); salsoda varies from 2,360 to 4,800 pounds per acre. The percentage of common salt and total salts is higher than for any other plant investigated, and the glauber salt is almost proportionate. The areas over which this plant grows must, therefore, be considered as among the most hopeless of alkali lands, for although its salts are 'white,' submergence during winter precludes the growth of Australian salt-bush.

"Bushy Samphire is a common plant in alkali soils in the Upper San Joaquin Valley, around Bakersfield and Delaro; a few stunted bushes occur near the margin of Tulare Lake, west of Tulare, but at that point it appears to be dying out. It also occurs on the east slope of Livermore Pass, and in an alkali sink in a pocket of the hills at

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Byron Springs, Contra Costa County. In the Death Valley region the plant appears to be very abundant, occupying an area considerably more southern than what appears to be the southerly limit of Greasewood (Sarcobatus). TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

"*Salt-worts* (Suaeda torreyana, *S. Wats.*, S. suffrutescens, *S. Wats., and perhaps one other species*).

"Samples of Salt-wort soil from Bakersfield, Kern County, and Byron Springs, Contra Costa County, taken to a depth of one foot and three feet, respectively, show that this plant grows luxuriantly in a soil containing 130,000 pounds of salts per acre in the first foot, and with 10,480 pounds of the noxious salsoda, and 39,760 pounds of common salt in three feet; while only a sparse growth is found on soils containing only 3,700 pounds of salts in three feet. It thus appears to indicate a lower percentage of salsoda than does Greasewood, but a higher percentage than Bushy Samphire Further investigation is necessary to determine the exact relation of the different salts to the growth of the plant, and as to whether carbonates always occur in large quantity; but enough data have been gathered to show that a luxuriant growth of Salt-wort indicates a soil practically irreclaimable except at the expense of leaching. Suaeda spp.

"Suaeda torreyana occurs in abundance in certain alkali soils near Bakersfield, Kern County; in a large alkali sink near Colusa Junction, Colusa County; in Honey Lake Valley, Lassen County; Antelope Valley, Kern County, and in the vicinity of San Bernardino. Coville reports having collected it at Lone Pine, Inyo County. The closely related species, S. suffrutescens, only to be distinguished by an expert botanist, occurs in abundance in the alkali soils of the Mojave Desert, Death Valley, the Tulare plains, and near Bakersfield. The different species of Salt-wort grow in similar habitats, and it is probable that the condition of the soil is approximately the same for each species. It thus indicates land that, while not capable of bearing ordinary crops, will probably allow the Australian salt-bush to succeed, at least with the aid of some gypsum.

"*Alkali-Heath* (Frankenia grandifolia *var.* campestris, *A. Gray*).

"Alkali-heath is perhaps the most widely distributed of any of our California alkali plants. Its perennial deep-rooting habit of growth, Frankenia grandifolia.

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TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

and flexible, somewhat wiry rootstock, which enables it to persist even in cultivated ground, render it a valuable plant as an alkali indicator. The salt content where Alkali-heath grows luxuriantly is invariably high, ranging from 64,000 to 282,000 pounds per acre; salsoda varies from 680 to 19,590 pounds, common salt ranges from 5,000 to 10,000 pounds. Such soils would not be benefited by the application of gypsum, as the salts are already largely in the neutral state. Of useful plants only Salt-bushes and Tussock-grass are likely to flourish in such lands.

"While Alkali-heath is thus one of the most alkali-tolerant plants, it is at the same time capable of growth with a minimum of salts (total salts 3,700 pounds, salsoda 680 pounds). Where only a sparse growth of this plant occurs, therefore, the land should not be condemned until a chemical examination of the soil has been made.

"Alkali-heath is found on soils of very varying physical texture and degrees of moisture; while on soils of uniform texture and moisture, but differing in chemical composition, it varies with the varying salt-content.

"It has been found that Australian Salt-bush (**Atriplex semibaccata**) can be successfully grown on the Colusa County 'goose lands,' on soil producing a medium crop of Alkali-heath; it remains to be shown whether it will do equally well on soils producing a dense and luxuriant growth of the same.

"Alkali-heath is so widely distributed throughout the interior valleys of California that it would be superfluous to give a list of the localities in which it occurs. A closely related form is found in salt marshes along the coast, differing from that of the interior principally in its much broader leaves.

Cressa cretica

Cressa (Cressa cretica *var.* truxillensis, *Choisy*).

"Cressa soils show a low percentage of the noxious salsoda, but comparatively heavy total salts (161,000 to 282,000 pounds per acre). Common salt varies from 5,760 to 20,840 pounds per acre in four feet. The maximum is lower than in the case of Alkali-heath, but Cressa seems to be much more closely restricted to strong alkali than does the former species. Cressa appears to be as widely distributed through the interior valleys of the State as Alkali-heath. It is a cosmopolitan plant, occurring as its name indicates, on the Ionian Isles, as well as in North Africa, Syria, and in other arid countries of the world.

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of Alkali Lands. (E. W. Hilgard)	REH

" RELATIVE TOLERANCE OF THE DIFFERENT SPECIES.

" In order to determine the relative nature of the soils characterised by each of the above-named plants, Mr. Davy has prepared the following table, in which the column marked *optimum* shows, as nearly as possible with our present knowledge of the subject, the condition of the soil where each species grows in about equal luxuriance. For Salt-wort and Dwarf Samphires we have not yet been able to obtain as thoroughly characteristic soil samples as could be desired, but we hope to be able to do so during the coming season. TOLERANCE OF SALINITY, IN CHARACTERISTIC CALIORNIAN PLANTS.

" It must be understood that the *optimum* indicates the condition under which the plant has been found at its greatest luxuriance—where it is evidently 'at home'— ; whereas the maximum and minimum have sometimes been obtained where the plants were more or less stunted in growth and sparingly scattered over the ground.

" Table showing Maximum, Optimum, and Minimum of Salts tolerated by each of the several Alkali Plants.

	Pounds per Acre		
	Optimum.	Maximum.	Minimum.
Total Salts.			
Bushy Samphire . . .	494,520	494,520	135,060
Dwarf Samphires . . .	441,880	441,880	441,880
Alkali-heath	{ 281,960 64,300 }	499,040	3,720
Cressa	281,960	281,960	161,160
Salt-worts	130,000	153,020	3,720
Greasewood	58,560	58,560	2,400
Tussock-grass . . .	49,000	499,040	49,000
Carbonates (Salsoda).			
Tussock-grass . . .	23,000	44,460	3,040
Alkali-heath	{ * 19,590 680 }	19,590	680
Greasewood	18,720	18,720	1,280
Dwarf Samphires . . .	12,120	12,120	2,200
Salt-worts	10,480	12,120	1,120
Cressa	5,440	5,440	680
Bushy Samphire . . .	4,800	4,800	1,500

* This plant grows with equal luxuriance in soils containing only 680 pounds of carbonates.

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TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

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* This plant grows with equal luxuriance in soils containing only 680 pounds of carbonates.

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TOLERANCE OF SALINITY IN CHARACTERISTIC CALIFORNIA PLANTS.

"*Table showing Maximum, Optimum, and Minimum of Salts, etc.*—contd.

	Pounds per Acre		
	Optimum	Maximum.	Minimum.
Chlorides (Common Salt).			
Bushy Samphire	212,080	275,160	56,800
Dwarf Samphires	125,640	125,640	125,640
Salt-worts	39,760	52,900	1,040
Cressa	20,840	20,840	5,760
Alkali-heath	{ 10,180 5,760 }	212,080	1,040
Tussock-grass	6,200	172,800	3,530
Greasewood	3,680	3,680	160
Sulphates (Glauber Salt)			
Dwarf Samphires	314,040	314,040	314,040
Bushy Samphire	277,640	277,640	50,080
Cressa	275,520	275,520	134,880
Alkali-heath	{ 275,520 34,530 }	323,200	1,560
Salt-worts	44,160	104,040	1,560
Greasewood	36,160	36,160	960
Tussock-grass	19,640	323,200	19,640

"In these tables the sequence of the different plants has been arranged so that in each case the species having the highest optimum comes at the head of the list. Arranged in this way the tables show that where these plants grow in luxuriance they may be considered indicative of the following conditions:—

"*Total Salt Indicators.*—The Samphires, Alkali-heath and Cressa are all indicative of excessive total salts. Salt-wort, Greasewood, and Tussock-grass indicate much lower salt-content; indeed, the maximum of the two latter plants (Greasewood and Tussock-grass) indicate much lower total salt-content; indeed the maximum of the two latter plants (Greasewood and Tussock-grass) is so low that the application of gypsum (land-plaster) would *in some cases* (*e.g.* the Tussock-grass lands near Bakersfield) render the soil adapted to the cultivation of Modiola and Australian Salt-bush.

"*Salsoda Indicator.*—It is noticeable that the relative position of the different species in the columns of optimum and maximum is more uniform in the salsoda table than in any other; and whether

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TOLERANCE OF SALINITY IN CHARACTERISTIC CALIFORNIA PLANTS.

we arrange the sequence of the plants according to the optimum or to the maximum, the same relative position is maintained. This is in complete accord with what our knowledge of the effect of salsoda on vegetable life would lead us to expect; being by far the most injurious of the alkali salts, the range of tolerance is much smaller, and the limits are much more clearly defined than in the case of the other salts.

"Luxuriant growths of Tussock-grass and Greasewood are invariably indicative of high percentages of carbonates, but in such cases the total salt percentage is sometimes so low that the application of gypsum (land-plaster) would render the land fit for the cultivation of Modiola or even Australian Salt-bush, as noted above. It must be borne in mind, however, that where Tussock-grass grows but sparsely, the total salt-content may reach 499,000 pounds, an amount rendering the land utterly worthless for agricultural purposes unless the surplus salts can be removed.

"Alkali-heath cannot be taken as an accurate guage of the salsoda content as it grows with equal luxuriance on soils containing, respectively, 680 and 19,590 pounds to the acre, of this salt.

"The Samphires and Salt-worts are relatively low down in the carbonate table, and may be taken to indicate a comparatively low percentage of 'black alkali.'

"***Neutral-Salt Indicators.***—The Samphires and Salt-worts head the neutral salt tables, and are reliable indicators of excessively high percentages both of glauber salt and of common salt. Salt-wort comes next to Samphire in the common-salt table, but is not quite such a good guide to the glauber salt.

"Luxuriant growths of Alkali-heath, Greasewood, and Tussock-grass indicate low percentages of the neutral salts, but these plants will sometimes tolerate (in a sparse state of growth) very high percentages."

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REH. | The Nature, Value and Utilisation

TOLERANCE OF SALINITY IN CHARACTERISTIC CALIFORNIA PLANTS

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Aristida setacea, *Retz.*
Atriplex nummularia, *Lindl.*
Calotropis gigantea, *R. Br.*
C. procera, *R. Br*
Canavalia obtusifolia, *DC.*
Capparis aphylla, *Roth.*
C. spinosa, *Linn.*
Casuarina equisetifolia, *Forst.*
Cenchrus catharticus, *Del.*
C. montana, *Nees.*
Eleusine ægyptiaca, *Pers.*
E flagellifera, *Nees.*
E. scindica, *Duthie.*
Elionurus hirsutus, *Munro.*
Indigofera *sp.*
Hydrophylax maritima, *Linn.*
Ipomœa biloba, *Forsk.*
Jatropha Curcas, *Linn.*
J. glandulifera, *Roxb.*
Launea pinatifida, *Cass.*
Melanocenchris royleana, *Nees.*
Opuntia Dillenii, *How.*
Pandanus odoratissimus, *Willd.*
Pennisetum cenchroides, *Rich.*
Perotia latifolia, *Ait.*
Pupalia orbiculata, *Wight.*
Saccharum ciliare, *Anders.*
Salvadora oleoides, *Dcne.*
S. persica, *Linn.*
Spinifex squarrosus, *Linn.*
Sporobolus orientalis, *Kunth.*
Tamarix gallica, *Linn.*
Zizyphus nummularia, *W. & A.*

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All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

(Crop Disease and Pest Series, No. 3).

THE

AGRICULTURAL LEDGER.

1901—No. 5.

SACCHARUM: SUGAR.

(DISEASES.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. II., S. 176-94.*]

DISEASES OF SUGAR-CANE IN BENGAL.

A Note by LIEUTENANT A. T. GAGE, M.A., M.B., B.Sc., I.M.S, *Curator of the Herbarium, Royal Botanic Gardens, Sibpur. (Reprinted from Bengal Bulletin No. 7—1900.) To which is added an Introduction* on the more important Sugar-cane Fungal Diseases of India *and an Appendix. By* THE EDITOR.

Other PAPERS that may be consulted:

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CALCUTTA:
OFFICE OF THE SUPERINTENDENT, GOVERNMENT PRINTING, INDIA.
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THE

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(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products to officials or other persons interested therein;

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To facilitate the preparation of an index to THE AGRICULTURAL LEDGER, the following arrangements have been made, commencing with 1900:—

All papers published will be paged, irrespective of subjects, into an annual volume.

The annual paging will be given on the top of the pages. But to permit of a continuation of the classification into the various series hitherto observed, a further folio will be shown at the bottom of the pages This will be preserved throughout each series and be continued for several years, until in *fact sufficient material in each series has been accumulated to constitute a* fair sized volume.

At the end of the year a printed index and title page will be issued, for the annual volume, and after a period of, say, five years an index and title page will be issued for each series. It has been found that many persons subscribe for a certain series of papers only and do not care to receive the others. The new arrangement, while permitting of the formation of an annual volume, will at the same time retain the serial classification.

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INTRODUCTION.

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Her late Majesty's Secretary of State for India by Despatch No. 83 (Revenue) of the 5th May 1898, forwarded certain communications from Sir William Thiselton-Dyer, Director of the Royal Gardens, Kew, on the subject of the sugar-cane disease of, and the remedial measures pursued in, Barbados and British Guiana. They were submitted to the Government of India for such action as His Excellency might see fit, but it was added that the Secretary of State desired to be informed hereafter whether the Indian experts identify the disease met with in India as being due .. .le fungus described in connection with Barbados, and, if so, the remedial measures recommended by Sir William ve been or may be tried in India and with what su

SACCHARUM: Sugar.

Diseases of Sugar-cane in Bengal.

INTRODUCTION.

The Government of India in submitting the above Despatch and its enclosures to the Officiating Reporter on Economic Products (Mr. D. Hooper) desired that an *Agricultural Ledger* should be at once prepared on sugar-cane disease, and that all the information given in the various issues of the Kew Bulletin from July 1893 to June 1896 on the Barbados disease should be incorporated in it, together with the reports published by Dr. Bourne regarding the disease as met with in the Madras canes. By letter No. 19—45-13 of the 18th November 1898, the Government of India submitted Her late Majesty's Secretary of State's Despatch to all Local Governments and Administrations (except Madras) and advised them of the *Agricultural Ledger* which, it was explained, would be found to republish the relevant information contained in the Kew Bulletins referred to by Sir William Thiselton-Dyer.

At the same time the Government of India desired the Madras Government to furnish Mr. Hooper with specimens of the diseased canes that had been the subject of Dr. Bourne's special reports. This latter circumstance brought the Office of Reporter on Economic Products into direct dealings with the Madras authorities. The Board of Revenue, Madras, have accordingly from time to time furnished my office with full particulars of Dr. Bourne's investigations and later with Mr. Barber's opinions. It may be here added that Mr. Barber having spent several years in the Leeward Islands (prior to his taking up the appointment of Botanist to the Madras Government), and while there having devoted considerable time to the study of the sugar-cane disease on the living plant, and subsequently while in England having given special attention to the study of the Barbados cane disease, may be regarded as an expert. Indeed it is a fortunate circumstance that India should thus possess a botanist of great ability and one who at the same time is conversant with the various manifestations or phases of this most perplexing and alarming disease.

It may, perhaps, be of interest in this connection to furnish here a very brief review of the History of the Chief Fungal Diseases of the Sugar-cane as having a bearing on the work accomplished by the Indian investigators.

I should like, however, to record that I make no profession of being a mycologist and desire to set forth the various opinions of the

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experts who have enquired into this subject from the practical point of view only. To attempt to criticise these opinions even when to the uninitiated they may appear contradictory, would be invidious and impertinent.

Papers on Sugar cane disease.

(*a*) Dr. Cobb in 1893 published in the *New South Wales Agricultural Gazette* certain particulars of a sugar-cane disease which he designated "Cane-Spume." He further gives it the scientific name of **Melanconium (=Strumella) Sacchari.**

(*b*) About the same time Dr. F. A. F. C. Went had been studying a disease in the Java sugar-canes which he calls "Pine-Apple disease," because of the peculiar smell of the affected stems, more especially in the early stages of the disease. He also furnished a scientific description of the fungus under the name of **Thielaviopsis ethaceticus.**

(*c*) Went very shortly after also described a second disease of the sugar-cane met with in Java. This, it would appear, causes the leaves to fade and the tissue of the stems to become stained with peculiar red blotches. He designated this second disease as "Red Smut" and gave it the scientific name of **Colletotrichum falcatum.**

(*d*) Mr. George Massee, a Principal Assistant at Kew, received in 1893 from the West Indies certain diseased canes. From the fact of the disease with which they were infested appearing on the rind it was called the "Rind fungus of the West Indies." The small black pustules seen on the surface of the canes were identified by Massee as corresponding with Cobb's "Cane Spume." By cultivating the spores derived from these pustules Mr. Massee obtained Micro and Macro-spores and these he accepted as practically identical with Went's **Thielaviopsis.** Moreover, Massee succeeded in carrying the cultivation still further and produced an Ascigerous stage. These observations very naturally led him to substitute for the name **Melanconium** the more comprehensive one of **Trichosphaeria Sacchari.** Accordingly the fungus as recognised by Massee is a polymorphous species with three phases in its life-history.

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(*e*) Shortly after the above observations had been recorded it would appear Massee had canes sent him for examination from Barbados. These were found to be affected by a root fungal disease. This Massee ascribed to Went's **Colletotrichum falcatum**. In the Kew Bulletin of 1895 Massee further definitely affirms that **Colletotrichum falcatum** is but another stage in the life-history of his species **Trichosphaeria Sacchari.**

(*f*) Mr. Barber in 1894 published an account of the root disease of the sugar-cane of Barbados (*Supplement, Leeward Islands Gazette*), from which it would appear highly probable that that disease may be quite distinct from **Colletotrichum falcatum**, although it may be but a form of the disease known in Java under the collective vernacular name of *Sereh*.

(*g*) In the *Annals of Botany* for 1896 Went criticises Massee's opinions and refuses to believe that any connection exists between **Melanconium** and **Thielaviopsis.** He further repudiates the acceptance of the association of the root disease or of **Colletotrichum falcatum** with **Trichosphaeria,** until Massee gives details of the experiments he had performed and which led him to advance that opinion.

(*h* and *i*) The Annals of Botany for December 1900 contains two papers—(h) a vindication of Massee's views by Sir William Thiselton-Dyer and (i) an account of new and Careful Observations in Barbados by Howard, whose further contributions may be hoped to settle the main matters under dispute. These papers have appeared too late for a fuller reference in this place. The discussion is however, of more than purely botanical interest. If, for example, **Colletotrichum** is not one of the phases of the polymorphous species **Trichosphaeria,** the eradication of these fungi would very possibly have to be accomplished by considerably different methods. The confirmation of Massee's opinions is, therefore, a consideration of the greatest practical importance to the sugar-cane cultivators. Indeed until Massee's experiments have been repeated and his opinions verified, I would

INTRODUCTION.

venture to suggest that it would seem almost desirable, in view of the practical considerations of the eradication of blight, to regard the sugar-cane as liable to at least the following diseases which may or may not be separate species:—

1st.—The Rind Fungus of the West Indies which it seems probable may embrace Cobb's "Cane-Spume" and Went's Java "Pine Apple Disease," in other words be the **Trichosphaeria Sacchari** as originally defined by Massee (= paragraph 5 (*d*) above).

2nd.—The "Red Smut" of Java, *viz.*, **Colletotrichum Sacchari** of Went (= paragraph 5 (*c*) above).

3rd.—The "Root-disease" of Barbados and Java—the latter being the dangerous *Sereh* of the Dutch botanists (= paragraph 5 (*f*) above).

Dr. Gage's Note here follows.

Scope of this paper.

This note embodies the result of examination of specimens of diseased sugar-cane collected from the various districts of Bengal, where sugar-cane is cultivated. The specimens were obtained through the Director of Land Records and Agriculture, Bengal, who considered it desirable to investigate the subject thoroughly. At first the specimens sent were not in every case suitable for investigation, very small pieces being sent or fragments which were quite decayed and mouldy. Accordingly a set of instructions was drawn up and sent to the Director of Land Records and Agriculture for communication to the officers entrusted with the collection of the diseased specimens. At the same time the officers from whose districts the diseased specimens were obtained were requested to furnish what information they could on the following points:—

(1) The vernacular name or names of the variety or varieties of cane sent.
(2) The relative proportion roughly of diseased to healthy canes.
(3) The mode of cultivation practised.
(4) The sort of soil on which the canes are grown.

The information obtained on these points is embodied in this report, so far as it bears on the results of examination. The writer of the report is, however, alone responsible for the results of the examination of the specimens of cane sent. Personal inspection of the

DISEASED CANES FROM —

sugar-cane-growing districts was not undertaken by the writer, and this has to be borne in mind in basing any inference on this report as to the kinds and prevalence of sugar-cane disease in Bengal.

For convenience of reference the various districts of Bengal from which specimens were obtained are considered in alphabetical order.

Bhagalpur.

BHAGALPUR.

Banka Subdivision —From this subdivision diseased specimens were received on two occasions. The first lot of specimens was received with memorandum No. 573 A., dated 14th February 1900. They showed clearly the presence of the fungus **Colletotrichum falcatum,** *Went*, the tissues of the cane being permeated by the hyphæ of the fungus, while its distinctive fructifications were present just above the nodes. No other diseased condition was detected.

The second lot of specimens was received towards the end of February. Three varieties were sent bearing the following names:—

(1) *Mandaria*. (2) *Rounda*. (3) *Poundi*.

They were said to be diseased in the following proportions respectively.—

(1) *Mandaria*	6 per cent. diseased.
(2) *Rounda*	2 "
(2) *Poundi*	2 "

Practically no information was given regarding the mode of cultivation. The soil is a sandy clay, manured generally with vegetable ash.

All these varieties of cane showed an appearance quite different from that presented by a cane typically affected with the fungus **Colletotrichum falcatum,** *Went*.

On the surface of the cane there was several small circular openings about the size of a large pin head or small shot hole.

The canes were somewhat flattened, and had a peculiarly light sort of feel. On splitting up the canes, the interior of each which was seen to have been transformed into white tough fibres, with a somewhat silky lustre These fibres were quite isolated, and could be torn up through the crumbling tissue of the nodes with ease and without breaking. The fibres were in fact the fibrovascular bundles of the cane, which had become quite separate from one another by the destruction of the inter-vascular cellular tissue. The cause of this destruction was not at first evident, but further examination of canes

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sent from other districts and showing the same appearance as the Banka ones, left no doubt on the matter. DISEASED CANES FROM:—

In almost all the other canes showing their interior transformed into strands of fibre, there were detected in abundance small beetles, *belonging evidently to the genus* Dinoderus. *These small beetles* were seen busily occupied in burrowing in all directions through the cane, and reducing the intervascular tissue to fine powder. They seemed to be particularly fond of congregating about the nodal tissue. They were repeatedly seen in the tunnels leading from the "shot holes" on the outside of the cane. Specimens of the beetles were submitted to Major Alcock, I.M.S., Superintendent of the Indian Museum, for identification. They proved to be new to the entomological collection there, and accordingly were sent to Europe for identification. They have been identified as Dinoderus minutus, *Fabricius.*

Owing to the destruction of tissues caused by this Dinoderus it was practically impossible to obtain microscopic sections of the tissues, and consequently it cannot be said definitely whether the fungus Colletotrichum falcatum, *Went*, was present or not. Probably enough it was, but its destructive effect was infinitesimal compared to the ravages wrought by the beetle.

Supoul subdivision.—Specimens of diseased cane from this subdivision, collected in March, were received with memorandum No. 1436 A., dated 10th April 1900.

The vernacular name of the variety sent is *Chinia*, or *Tikh*, or *Kelari*. It is grown on a sandy clay soil.

The percentage of diseased cane said to be about 2·5 per cent.

The specimens showed precisely the same appearance as the second lot of canes sent from the Banka subdivision. Dinoderus was found burrowing all through the tissues; Colletotrichum falcatum, *Went*, probably also present, but if so, of quite secondary importance.

BANKURA.

From this district specimens were received with memorandum No. 1021 A. of 19th March 1900. Bankura.

The vernacular name of the variety sent is *Bhoori*. The amount of disease said to be about 12 per cent.

The presence of Colletotrichum falcatum, *Went*, was evident from the naked-eye appearance of the cane and red patches

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DISEASED CANES FROM—

in the tissues, and was confirmed by microscopic observation. The presence of **Dinoderus** was not noted.

Sadar and Vishnupur subdivisions.—From these subdivisions of the Bankura district canes were received with memorandum No. 522 A. of 9th February 1900. The results of examination were the same as those already given for the canes sent with memorandum No. 1021 A.

BEHEEA—E. I. R.

Beheea

Specimens of diseased cane from this district were received with memorandum No. 868 A. of 7th March 1900. Four varieties were sent—

(1) *Mango* said to be diseased 50 per cent.
(2) *Bhoorli* " " " 75 "
(3) *Bansahi* " " " 50 "
(4) *Katar* " " " 37 5 "

(1) On examination *Mango* showed the characteristic appearance of the destruction of tissues by **Dinoderus** It was doubtful if the specimens were affected with the fungus **Colletotrichum falcatum,** *Went.*

(2) *Bhoorli* showed precisely the same appearance as *Mango.*

(3) *Bansahi* specimens showed very clearly the presence of the fungus **Colletotrichum falcatum.** There was also slight destruction due to **Dinoderus.**

(4) *Katar.*—Of this variety, only a small fragment was sent and nothing definite was discovered.

BOGRA.

Bogra.

Specimens were received from this district with memorandum No. 1529 A. of 17th April 1900. They were examined in the usual way, and the presence of both the fungus and the beetle was easily demonstrated.

No report was received from the district as to the percentage of disease, etc.

BURDWAN.

Burdwan.

Specimens received with memorandum No. 1843 A. of 25th May 1900. The varieties of cane sent were named (1) *Kunri,* (2) *Shamsara,* (3) *Puri,* (4) *Kajooli,* (5) *Basta.*

DISEASED CANES FROM.—

Disease percentage said to be 25 per cent. Examination showed all five varieties to be affected with both Colletotrichum falcatum, *Went*, and with Dinoderus.

Khulna subdivision.—Two varieties of cane were received from this subdivision with memorandum No. 227 A. of 23rd January 1900. Both the varieties sent were unnamed and undistinguished in any way. They are here called (*a*) and (*b*)—

(*a*) Consisted of two small fragments of a greenish yellow-stemmed variety. They showed little or no appearance of disease externally, except a few reddish discoloured patches on the rind here and there. On section, however, well-marked red patches were seen, occupying half or more of the area of the section, and continuous at places with the discoloured patches on the rind. One or two large bore holes were also seen, showing where a grub had bee[illegible] branching fr[illegible] pearance of [illegible]

(*b*) Consisted of two small portions of a purple-stemmed variety. They showed the same naked-eye appearance as the greenish yellow-stemmed variety (*a*), but on microscopic examination hyphæ were not detected in the sections examined.

Raniganje subdivision.—Specimens were received from this subdivision with memorandum No 779 A of 3rd March 1900. They showed the typical macroscopic and microscopic appearance of disease due to Colletotrichum falcatum, *Went.*

DACCA.

Dacca.

Specimens were received on two occasions from this district. The first lot accompanied memorandum No. 571 A. of 14th February 1900. On that occasion the specimens consisted of two small pieces of cane quite dried up and useless for investigation purposes.

The second lot of specimens were received with memorandum No. 1526 A. of 17th April 1900, and were distinctly better examples. The cane sent had the various vernacular names of *Auck*, *Ganna* or *Gaudari*, *Kooshur*, *etc.* The disease percentage said to be from 10 to 20 per cent.

On examination hyphæ of Colletotrichum falcatum, *Went*, were found in abundance in the tissues; Dinoderus was also present but not to any great extent.

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DISEASED CANES FROM—

in the tissues, and was confirmed by microscopic observation. The presence of **Dinoderus** was not noted.

Sadar and Vishnupur subdivisions.—From these subdivisions of the Bankura district canes were received with memorandum No. 522 A. of 9th February 1900. The results of examination were the same as those already given for the canes sent with memorandum No. 1021 A.

BEHEEA—E. I. R.

Beheea

Specimens of diseased cane from this district were received with memorandum No. 868 A. of 7th March 1900. Four varieties were sent—

(1) *Mango* said to be diseased 50 per cent.
(2) *Bhoorli* „ „ „ 75 „
(3) *Bansahi* „ „ „ 50 „
(4) *Katar* „ „ „ 37 5 „

(1) On examination *Mango* showed the characteristic appearance of the destruction of tissues by **Dinoderus** It was doubtful if the specimens were affected with the fungus **Colletotrichum falcatum,** *Went.*

(2) *Bhoorli* showed precisely the same appearance as *Mango.*

(3) *Bansahi* specimens showed very clearly the presence of the fungus **Colletotrichum falcatum.** There was also slight destruction due to **Dinoderus.**

(4) *Katar.*—Of this variety, only a small fragment was sent and nothing definite was discovered.

BOGRA.

Bogra.

Specimens were received from this district with memorandum No. 1529 A. of 17th April 1900. They were examined in the usual way, and the presence of both the fungus and the beetle was easily demonstrated

No report was received from the district as to the percentage of disease, etc.

BURDWAN.

Burdwan.

Specimens received with memorandum No. 1843 A. of 25th May 1900. The varieties of cane sent were named (1) *Kunri,* (2) *Shamsara,* (3) *Puri,* (4) *Kajooli,* (5) *Basta.*

DISEASED CANES FROM:— Faridpur.

FARIDPUR.

Specimens from this district were received with memorandum No. 607 A. of 16th February 1900. They all showed extensively the effects of **Dinoderus**, though the insect itself was not seen.

Colletotrichum falcatum, *Went*, was not positively detected.

Jaipur Estates.

JAIPUR.

Three varieties of cane were received from the Jaipur Government estates with memorandum No. 1431 A. of 10th April 1900.

The three varieties sent were—

(1) *Belati*, said to show about 6 per cent. diseased.
(2) *Bheula Mukhi* „ „ very little disease.
(3) *Nori* „ „ „ „

All three varieties showed evidence of being attacked both by **Colletotrichum falcatum**, *Went*, and by **Dinoderus**. On the variety *Bheula Mukhi* the characteristic fructifications of **Colletotrichum falcatum**, *Went*, were present.

Jessore.

JESSORE.

Bongong subdivision.—Four specimens of diseased canes were received from this subdivision with memorandum No. 447 A. of 1st February 1900.

Colletotrichum falcatum, *Went*, was easily demonstrated in the specimens sent. The presence of **Dinoderus** was not noted.

Jhenida subdivision.—From this subdivision a variety cane, '*Nota*,' was received with memorandum No. 1434 A. of 10th April 1900. The diseased canes said to be about 12 per cent.

The specimens sent were badly destroyed by **Dinoderus**.

Colletotrichum falcatum, *Went*, was not positively demonstrated.

Narail subdivision.—Specimens were received from this subdivision on two occasions. The first lot of specimens were received with memorandum No. 398 A. of 29th January 1900.

They showed the characteristic appearance of disease due to **Colletotrichum falcatum**, *Went*, which was also demonstrated microscopically. The canes were evidently attacked also by **Dinoderus**, as a few shot holes were seen, but the chief destruction in this case was due to the fungus.

DISEASED CANES FROM.— Darbhanga.

DARBHANGA.

Specimens of diseased cane were received from this district on two occasions. The first lot was received with memorandum No. 1438 A. of 10th April 1900 Two varieties were sent—*Reora* from Saran district and *Bhuli* from Darbhanga. 25 per cent. of the canes in Saran were said to be diseased, and from 15 to 25 per cent. in Darbhanga.

The excellent report of the Settlement Officer, North Bihar, a copy of which accompanied the specimens, draws attention to the fact that the sugar-cane cultivators dread the disease known as '*Pilna*' far more than they do the effects of Colletotrichum falcatum, *Went*. *From the description of '*Pilna*' I have no doubt that* it is due to Dinoderus, which has already been so frequently referred to

The specimens of cane sent were undoubtedly affected with Colletotrichum falcatum, *Went*, but Dinoderus was responsible for most of the destruction.

The second lot of diseased cane from Darbhanga was received with memorandum No. 1525 A. of 17th April. The specimens showed precisely what the first lot did.

DINAJPUR.

Dinajpur.

Specimens of diseased cane were sent from this district on two occasions. The first lot was received with memorandum No. 730 A. of 28th February 1900. The canes of this lot showed the characteristic appearance of disease due to Colletotrichum falcatum *Went*. Dinoderus *was not seen.*

The second lot of specimens were received with memorandum No. 1652 A. of 27th April 1900. Five varieties were sent, bearing the following vernacular names—(1) *Mugi*, (2) *Sahebani*, (3) *Kheri*, (4) *Kajla*, (5) *Banusha*. About 5 per cent of each variety was said to be diseased.

All five varieties showed microscopic evidence of the presence of Colletotrichum falcatum, *Went*, in the tissues. Far more evident, however, and much more important as a destructive agent was Dinoderus. This beetle was present in strength, travelling *through and breaking down the tissues in every direction,* leaving the fibro-vascular bundles standing out like strands.

presence of **Colletotrichum falcatum**, *Went*, was not definitely made out. DISEASED CANES FROM:—

Jamni subdivision.—From this subdivision specimens were received on three different occasions Jamni subdivision of Monghyr.

The first lot came with memorandum No. 1433 A. of 10th April 1900. This included three varieties from Jamni itself named—

(1) *Mango.* | (2) *Maneria.*
(3) *Rounda.*

50 per cent. of those varieties were said to be diseased. In none of these three varieties was the presence of **Colletotrichum falcatum**, *Went*, positively demonstrated. **Dinoderus** was, however, very much in evidence.

From Barbigha police-station three varieties were received at the same time—

(1) *Chinia.* | (2) *Ketar.*
(3) *Mango.*

All three showed the destructive effects of **Dinoderus**, but **Colletotrichum falcatum** was probably also present, though not positively demonstrated.

The second lot of specimens from Jamni subdivision was received with memorandum No. 1527 A. of 17th April 1900.

The specimens were sent from Sikandra police-station and were of four kinds—

(1) *Sakor Chinia.* | (3) *Mango.*
(2) *Maneria.* | (4) *Rounda.*

25 per cent. of the canes were said to be diseased. The results of examination of the specimens were practically the same as those got from examination of the first lot. The greatest amount of destruction was caused by **Dinoderus**, the effects of **Colletotrichum falcatum** being relatively insignificant.

The third lot of specimens were received with memorandum No. 1528 A. of 17th April. The specimens were sent from two places—

From Saikpora police-station were sent—

(1) *Chinia.* | (2) *Maneria.*
(3) *Rounda.*

From Chakai outpost, Nawadih, were sent—

(1) *Maneria.* | [illegible]

DISEASED CANES FROM.— The second lot of specimens were received with memorandum No. 866 A. of 7th March 1900.

Two varieties were sent,—*Dhulsundur* and *Kajli.* About 25 per cent. were said to be diseased. Both varieties showed practically the same appearance as the canes of the first lot sent.

MIDNAPUR.

Midnapur. Specimens were received from this district with memorandum No. 1430 A. of 10th April 1900.

Four varieties were sent :—

(1) *Shamsara.*
(2) *Bombai.*
(3) *Bhoori.*
(4) *Kajli.*

The disease percentage was given as 25.

All four varieties showed the effects of both **Colletotrichum falcatum,** *Went,* and **Dinoderus.** It was difficult to determine which predominated.

Ghatal subdivision. *Shamsara* variety of cane was received from this district with memorandum No. 1531 A of 17th April 1900.

The disease percentage was given as 25. In the specimen sent **Colletotrichum falcatum,** *Went,* was demonstrated microscopically. The presence or work of **Dinoderus** was not noted.

Tamluk subdivision.—The same variety of cane, *Shamsara,* was received from this subdivision with memorandum No. 1435 A. of 10th April 1900.

20 per cent of the canes were said to be diseased.

The specimens from this subdivision showed unmistakeable, evidence of fungal hyphæ in the tissues. The real destruction, however, was due to the presence in abundance of **Dinoderus** which was busily crumbling the tissue to powder.

MONGHYR.

Monghyr. ***Begusarai subdivision.***—Specimens of cane were received from this subdivision with memorandum No 1023 A. of 19th March 1900.

The variety sent was *Bhooli.* About 5 per cent. of canes were said to be diseased.

The specimens showed very clearly the work of **Dinoderus,** which was present in considerable numbers. The whole interior of the canes sent was converted into strings of isolated fibres. The

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DISEASED CANES FROM :—

NOAKHALI.

Noakhali.

Specimens were received from this district with memorandum No. 921 A. of 10th March 1900.

Khagra was the variety sent.

Less than 1 per cent. was said to be diseased.

The specimens sent seemed to be affectedch iefly with **Dinoderus.**

It was doubtful if **Colletotrichum falcatum,** *Went,* was present.

PABNA.

Pabna.

Specimens of diseased cane from this district were received with memorandum No. 919 A. of 10th March 1900. Two varieties were sent called :—

(1) *Kazla,* of a dark purple colour.
(2) *Dhalsundar,* of a yellow colour.

From 12 to 50 per cent. were said to be diseased. The report of the Collector of Pabna lays special stress upon the destruction wrought by the pest "*Bonga.*" This, it is presumed, is the same pest as is mentioned in the report of the Subdivisional Officer of Kushtia, referred to under Nadia, although in the Pabna report the pest is referred to as a 'worm,' presumably from the "worm-eaten" appearance of the cane. Both varieties sent showed the effects both of **Colletotrichum falcatum,** *Went,* and of **Dinoderus.**

PURNEA.

Purnea.

Specimens were received from this district with memorandum No. 777 A. of 3rd March 1900. The variety sent was unnamed. 10 to 15 per cent. were said to be diseased. The hyphæ of **Colletotrichum falcatum,** *Went,* were easily detected in the tissues of the specimens sent. The presence of **Dinoderus** was not noted.

RANGPUR.

Rangpur.

Specimens from this district were received with memorandum No. 1650 A. of 27th April 1900. The variety sent was *Bhanda Mugi.* The specimens were affected chiefly with **Colletotrichum falcatum,** *Went,* and to a smaller extent with **Dinoderus.**

DISEASED CANES FROM — Saran.

SARAN.

From this district specimens of diseased cane were received on three occasions.

Two varieties—*Bhurli* and *Chinia*—were received with memorandum No. 1432 A. of 10th April 1900. The *Bhurli* canes were supposed to show three diseases—*Lohi, Murari*, and *Ukhra*, while *Chinia* was supposed to show only *Murari* and *Ukhra*.

Examination disclosed merely the usual diseased state, the effects of **Colletotrichum falcatum**, *Went*, and of **Dinoderus** being present in varying proportions.

Gopalgunge subdivision.—Specimens were received from this subdivision with memorandum No. 1530 A of 17th April 1900 and with memorandum No. 783 A. of 3rd March 1900.

All the specimens received showed the effects of **Colletotrichum falcatum**, *Went*, and of **Dinoderus** in varying proportions.

Sadar subdivision.—Specimens of the *Bhooli* variety of cane were received from this subdivision with memorandum No 732 A. of 28th February 1900.

They showed the effects of **Dinoderus**. The presence of **Colletotrichum falcatum**, *Went*, was not clearly made out.

SHAHABAD.

Shahabad.

Specimens received with memorandum No. 400 A. of 29th January 1900.

Three small fragments of cane were received in not very good state. They appeared to be attacked with **Colletotrichum falcatum**, *Went*.

SIBPUR EXPERIMENTAL FARM.

Sibpur.

From this place, three varieties were received with memorandum No. 218 A. of 16th January 1900.

Khari, Shamsara, and *Patnai Kusur* were the varieties sent.

Nothing could be made out of the *Patnai Kusur* specimen, as it was quite desiccated.

Khari and *Shamsara* appeared to be affected with **Colletotrichum falcatum**, *Went*. They also showed "shot holes," but **Dinoderus** was not actually seen.

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TIPPERA.

DISEASED CANES FROM:— Tippera.

Specimens were received on two occasions from this district with memorandum No. 575 of 14th February 1900 and memorandum No. 781A. of 3rd March 1900.

The presence of **Colletotrichum falcatum**, *Went*, was microscopically demonstrated. The presence of **Dinoderus** was not noted.

SUMMARY.

SUMMARY.

Out of a total of at least 79 sets of diseased canes examined, in only 10 was **Colletotrichum falcatum**, *Went*, alone found. In 7 **Dinoderus** alone was found. In 3 nothing definite was discovered. One showed the effects evidently of the grub of some moth, but the grub itself was not seen The remainder showed **Colletotrichum falcatum**, *Went*, and **Dinoderus** associated with the destructive effects on the tissues peculiar to each in varying degrees

The disease percentages given vary from 1 to 75. The average is about 23·5.

Dinoderus the most destructive pest.

The writer personally is inclined to rate **Dinoderus** as considerably more destructive to the cane than **Colletotrichum falcatum**, *Went*, judging merely from the specimens sent.

From the data it is impossible to say whether the beetle prepares the way for the easy entrance of the fungus or whether the fungus renders the cane more acceptable to the beetle. The fact is the beetle and the fungus were found to be associated with extreme frequency, in the specimens sent.

The fungus is named throughout this report **Colletotrichum falcatum**, *Went*. It agrees exactly with the description of that fungus as regards its appearance in the cane tissues, its fructification, and its development in cultures in sugar-cane solution.

It is beyond the scope of this report or the province of the writer to discuss the question whether **Colletotrichum falcatum**, *Went*, is a form of **Trichosphæria Sacchari**, *Massee*, or a quite different fungus.

Method of Cultivation.—The question regarding the modes of cultivation practised was answered in a somewhat perfunctory manner.

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SACCHARUM: Sugar. — Diseases of Sugar-cane in Bengal.

SUMMARY.

Only one report, that of the Settlement Officer of North Behar, takes the trouble to mention whether any other crop than sugar-cane is grown on the same land. The soil in most cases is described as a sandy clay. Judging merely from the answers received, the cane is in all cases propagated either by tops or cuttings, the former being the tops of the canes cut off before crushing the remainder, the latter being any joint having a bud. Ratooning, that is, allowing the new shoots to spring from the old roots of the preceding year's crop, is not mentioned in any of the reports as being practised.

Conditions favouring disease.

As regards the conditions favouring the diseases found in the specimens sent, and the common sense remedies to be employed in combating them, the writer cannot do better than quote some remarks from the excellent report, already referred to, sent in by J. H. Kerr, Esq, C.S, the Settlement Officer for North Behar:—"The cultivators all, however, agree that the disease (that is, the fungus disease) is much aggravated, if it is not actually caused, by stagnant rain water lying on the ground, and well-drained fields appear to enjoy immunity from the disease. Few of the cultivators, however, are able or willing to take the trouble to do this properly, *i.e.*, drain their fields. Another cause is the careless selection of infected slips of cane for planting. Some old cultivators say, that the introduction of the new iron mills, which have been general during the last ten years has led to greater carelessness in this matter. The old primitive country mills were fed with small cuttings of cane about six inches long, and thus the interior of every cane was examined, and those which showed symptoms of the disease were rejected for plantation purposes. The new mills, on the other hand, are fed with whole canes, and, it is said, so much care is not now exercised in selecting cuttings for planting purposes as formerly. Much may be done to prevent the disease by careful selection of healthy slips for planting purposes, and by proper drainage of the land."

The writer has merely to add the suggestions that where the disease is particularly prevalent, the ground should be thoroughly cleared out of all cane, and all decaying rubbish burned, and some other crop or crops than sugar-cane grown for one or two years, at least.

No doubt, if all this were thoroughly done, the disease could be stamped out, but is to be feared that the advice is but a counsel of perfection to the ordinary raiyat.

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SUMMARY.

For a comprehensive account of sugar-cane, its culture, its enemies, and its diseases, and modes of treatment thereof, the reader is referred to Krueger's Das Zuckerrohr und seine Kultur, Magdeburg, 1899, where there is also to be found the bibliography of the subject.

Tabular statement giving results of examination of canes.

The table given below shows the disease percentages and the results of examination of the specimens sent in a concise form. In some the disease percentages and vernacular names are not given, as these specimens were forwarded before instructions on these points were issued.

District	Variety of cane.	Disease percentage.	Results of Examination.
1	2	3	4
Bhagalpur— Banka subdivision .	(1) Mandarla .	6	Dinoderus and probably Colletotrichum falcatum
	(2) Rounda . .	1	Ditto ditto.
	(3) Poundi . .	2	Ditto ditto
Supoul ditto .	(1) Chinia, Tikh, Ketari.	2 5	Ditto ditto
Bankura—	Bhoori .	12	Colletotrichum falcatum, *Went.*
Sadar and Vishnupur subdivisions.	Not given	Not given	Ditto.
Behera—	(1) Mango . .	50	Dinoderus
	(2) Bhooris . .	75	Ditto
	(3) Bansahi . .	50	Colletotrichum falcatum, *Went.*, and Dinoderus
	(4) Ketar . .	37 5	Not definite discovered
Bogra—	Unnamed .	Not given	Colletotrichum falcatum, *Went.*, and Dinoderus.
Burdwan—	(1) Kouri	25	Ditto ditto
	(2) Shamsara		Ditto ditto
	(3) Puri		Ditto ditto
	(4) Kajooli		Ditto ditto.
	(5) Basta		Ditto ditto
Khulna subdivision.	Variety (a) .	Not given	Ditto ditto
	„ (b) .	„	Nothing detected.
Raniganj ditto .	Kowle .	„	Colletotrichum falcatum, *Went.*
Dacca—	Auck, Gaona, etc.	10—20	Colletotrichum falcatum, *Went.*, abundant and Dinoderus also present
Darbhanga—	Bhuli . . .	15—25	Colletotrichum falcatum, *Went.*, and Dinoderus in abundance
Dinajpur . . .	I Unnamed .	Not given	Colletotrichum falcatum, *Went.*
	II (1) Mugi . .	5	Colletotrichum falcatum, *Went.*, undoubtedly present, but the destruction chiefly caused by Dinoderus, present in abundance
	(2) Saheban .	5	
	(3) Kheri .	5	
	(4) Kajla .	5	
	(5) Bansiba .	5	
Faridpur . . .	Unnamed . .	Not given	Chief destructive agent Dinoderus Colletotrichum falcatum, *Went.*, also present
Jaipur . . .	(1) Beiati .	6	Colletotrichum falcatum, *Went.*, and Dinoderus
	(2) Dhenla Mukhi.	Very little	Ditto ditto.
	(3) Neri . .	—	Ditto ditto.

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SACCHARUM: Sugar.

Diseases of Sugar-cane in Bengal.

SUMMARY.

DISTRICT	Variety of cane	Disease percentage.	RESULTS OF EXAMINATION.
1	2	3	4
JESSORE—			
Bongong subdivision	Unnamed	Not given	Colletotrichum falcatum, *Went*
Jhenida ditto	Nota	12	Dinoderus present
Narail ditto	I Unnamed	Not given	Colletotrichum falcatum, *Went*, chiefly
	II (1) Dhulsunder	25	Ditto ditto
	(2) Kajli	25	Ditto ditto.
MIDNAPUR	(1) Shamsara	25	Colletotrichum falcatum, *Went*, and Dinoderus were present in about equal proportions
	(2) Bombai	25	
	(3) Bhoori	25	
	(4) Kajli	25	
Ghatal subdivision	Shamsara	25	Colletotrichum falcatum, *Went*.
Tamluk ditto	Ditto	20	Dinoderus chiefly, Colletotrichum also present.
MONGHYR—			
Begusarai subdivision	Bhooli	5	All these specimens showed the greatest amount of destruction caused by Dinoderus. The effects of Colletotrichum falcatum, *Went*, if present at all, being relatively insignificant.
Jamni subdivision	(1) Mango	50	
	(2) Maneria	50	
	(3) Rounda	50	
Barbigha police station.	(1) Chinia		
	(2) Ketar		
	(3) Mango		
Sikandra police station	(1) Sakar Chinia	25	
	(2) Maneria	25	
	(3) Mango	25	
	(4) Rounda	25	
MONGHYR—			
Shaikpora police-station.	(1) Chinia	20—25	*All those specimens* showed much more the effects of Colletotrichum falcatum, *Went*, than of Dinoderus
	(2) Maneria		
	(3) Rounda		
Chakai outpost, Nawadih	(1) Maneria		
	(2) Rounda		
MURSHIDABAD	(1) Shiti	50	Colletotrichum falcatum, *Went*, and Dinoderus
	(2) Kajla	50	Attacked by the grub of a moth undetermined
MYMENSING	Unnamed	Not given	Colletotrichum falcatum, *Went*, chiefly
NADIA	(1) Shamsara	25	Colletotrichum falcatum, *Went*, and Dinoderus
	(2) Dhali	25	Ditto ditto.
	(3) Kazli	25	Dinoderus
NOAKHALI	Khagra	1	Ditto.
PABNA	(1) Kazla	12—50	Colletotrichum falcatum, *Went*, and Dinoderus
	(2) Dhalshundur	12—50	Ditto ditto
PURNEA	Unnamed	10—15	Colletotrichum falcatum, *Went*
RANGPUR	Bhanda Mugi	...	Colletotrichum falcatum, *Went*, chiefly
SARAN	Reora	25	Dinoderus *chiefly, but* Colletotrichum falcatum also present.
	Bhuli	Not given	Colletotrichum falcatum, *Went*, and Dinoderus
Gopalgunge subdivision	Chinia	,,	Ditto ditto.
	Unnamed	,,	Ditto ditto
Sadar subdivision	Bhuli	,,	Dinoderus
SHAHABAD	Unnamed	,,	Colletotrichum falcatum, *Went*
SISPUR EXPERIMENTAL FARM.	(1) Khari	,,	Apparently Colletotrichum falcatum
	(2) Shamsara	,,	Ditto ditto
	(3) Patnai kusir	,,	Nothing made out
TIPPERA	Unnamed	,,	Colletotrichum falcatum, *Went*.

RECOMMENDED REMEDIES

APPENDIX.

The question is often asked how far have the remedial measures pursued in Barbados been tried in India.

The recommendations contained in the *Kew Bulletins* might be summarised in the following rules :—

1st.—The best plants must be selected from uninfected areas and before planting should be dipped in disinfection solutions.

2nd.—Cut out and destroy the diseased canes all through the growing season and burn them carefully, *if possible, on the spot.*

3rd.—Destroy all trash, stumps, etc., *by burning* after the crop has been reaped.

4th.—Carry out rotation of crops, where possible, having previously destroyed all the trash, stumps, etc., (according to rule 3).

5th.—Aim at the production of or discovery in other localities of immune varieties.

6th.—Where root disease is present ratooning should be abandoned.

As having a bearing on these recommendations it may be as well to point out that Went lays great stress on the fact that Colletotrichum falcatum is an internal fungus. That is to say, it is produced within the issue of the stem, whereas the rind-fungus (Trichosphæria) may be spoken of as external. Stems containing the former fungus may be cut down and carried to a distance without risk of distributing the disease to neighbouring canes. Stems with the latter would shed the spores and widely distribute the pest, if carried from one field to another. Went further explains that if Colletotrichum bearing stems be allowed to dry they become dangerous. He accordingly urges that canes containing Colletotrichum should be burned while still wet. It would thus follow that stems with rind-fungus must be destroyed on the spot (Rule 2 above). It would seem that the recommendations to avoid ratooning has special reference to the root disease. It has in fact been affirmed that sugar-cane affected by rind-fungus may yield a fairly good second crop on a ratooning stock and that that

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RECOMMENDED REMEDIES

particular disease is not thereby necessarily perpetuated by the act of ratooning (Rule 6).

So in the same way the burning of the trash (*e.g.*, leaves, Rule 3) would appear to have its foundation mainly in the circumstance that in Mauritius the cane-boring moth is credited with spinning its cocoons in the decaying leaves. In countries with a distinct winter the possibility of such hibernation is doubtless an important consideration. The burning of the trash has the advantage no doubt of destroying any spores that may fall from the stems in addition to eradicating insect pests, but we are unaware that any one of the three fungal diseases here more especially dealt with has a resting stage in the leaves. On the other hand, the act of burning the trash removes a large and important source of manure, and the practice has by some planters been condemned.

Selection of *shoots.*

With regard to the selection of shoots to be employed as seed (Rule 1), a difference of opinion would seem to prevail even among European planters and scientific writers. In India the natives select *from their fields as seed only the hard and less succulent canes, or* portions of canes, the canes in fact that would yield little sugar. This view is supported by some West Indian planters who affirm that the plants thus obtained are more healthy and vigorous. On the other hand, as the result of recent experiments it has been urged that only the canes most succulent and richest in sugar should be so employed, the resulting crop being rich in sugar. The idea would seem to be that while you may lose in vigour you gain sugar-yielding capacity, by the selection of the very best shoots as seed. But of course in both cases the plants selected for propagation must be free from disease.

But while different opinions may exist on one or two of the recommendations advanced by the Kew authorities, Rules 4 and 5 have met with universal acceptance. *It is perhaps safe to affirm* that the improvements effected in the eradication of cane-diseases have mainly, if not entirely, proceeded from the cultivation of immune stock in place of that found liable to disease (Rule 5). In fact the above recommendations (except the selection of immune stock) may be said to be covered by the adoption of ordinary systems of clean and careful agriculture. In India rotation of crops (Rule 4) is universally pursued, and always has been. Sugar-cane cultivation occupies but a very small percentage of the ryot's lands. The plots

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RECOMMENDED REMEDIES.

selected for sugar-cane are heavily manured, the principle being universally accepted that the succeeding crops benefit very largely thereby. In fact sugar-cane is in India cultivated (in the vast majority of districts) according to systems that leave little room for improvement. It is a very profitable article and will pay for higher cultivation than can be bestowed on almost any other field crop. In few instances accordingly are the selected plots again brought under sugar-cane sooner than after an interval of three years. In the West Indies and other parts of the world, on the other hand, rotation is next to impossible.

Recommended in India.

The following passages from the official replies to the Government of India's enquiries as to the adoption of the Barbados methods may be here given:—

Madras—Dr. Bourne (Madras Government Proceedings No. 127, 127 A. of the 3rd March 1898, page 4, and again in Board's Proceedings No. 151 of 3rd June 1899, page 8) practically gives the recommendations which have already been recorded as those published in the Kew *Bulletins*. He does not say how far these have been adopted by the Indian cultivators. On the other hand, Mr. V. A. Brodie, Collector of Godaveri, characterises Dr. Bourne's recommendations as drastic and adds that he is very doubtful if "the ryots will adopt them till driven to do so by further losses, for they do not coincide with any of their views which are that the reddish fungoid growth spoken of by Dr. Bourne is a consequence and not a cause of the disease."

Mr Barber (with special reference to Sereh or the somewhat similar disease found by him in Coimbatore) recommends ratooning to be abolished; to obtain Sereh-free stock; to procure immune varieties; and to practise a rotation of crops (Madras Board of Revenue Proceedings No. 151, dated 3rd June 1899 page 17).

Bengal.—The Director of Agriculture remarks that this province is not at present very seriously affected by any disease. The Collectors of Nadia and Pabna refer to the methods pursued in destroying insect pests, but in none of the Bengal returns is any mention made of the treatment of fungal blights.

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RECOMMENDED REMEDIES

North-Western Provinces.—The Director of Land Records and Agriculture, referring to a fungal pest, says that "the remedies adopted by the cultivators consist of the selection of healthy seed and of the abandonment of those varieties that suffer most."

Punjab and Central Provinces.—In the Punjab no disease has been recorded, and of the Central Provinces no special remedial measures are mentioned.

Bombay.—No report furnished of the remedial measures pursued.

Burma and Assam.—No mention made of special measures being adopted to combat fungal disease if present.

There would thus appear to be no further remarks to offer on this subject than have already been made. India has periodically suffered from severe outbreaks of cane disease, most of which have been very possibly of a fungal nature. But it may, in conclusion, be repeated that a rotation of crops is universally practised and that the principle of selection of immune stock is also well known and very generally followed. It would seem that these two measures are of the utmost importance, and accordingly that they should on every opportunity be urgently recommended to the attention of cultivators who may not be aware of their vital importance. In badly affected areas it may be desirous that State aid should be extended to enable the cultivators to procure stock of immure forms.

EXPLANATION OF PLATE.

Fig. (*1*)—Node of cane showing fructifications **Colletotrichum falcatum,** *Went,*—little black dots appearing under a lens like tufts of minute black hairs. Nat. size.

Fig. (*2*)—Longitudinal section through portion of cane affected with **Colletotrichum falcatum,** *Went.* Nat. size. To be contrasted with Fig. 10.

Fig. (*3*)—Portion of section through a fructification seen in Fig. 1. The fungus mycelium shows a stroma, giving rise to rigid multicellular hairs. The conidia or reproductive bodies lie between the hairs. They are not represented. Mag. $\frac{240}{1}$. Semi-diagrammatic.

Fig. (*4*)—Two conidia isolated. They are set free in myriads from the fructification tufts. Mag. $\frac{240}{1}$.

Figs. (*5*) *and* (*6*)—A conidium germinating in an artificial sugar-cane culture after 24 hours.

Fig. (*7*)—After 36 hours' growth. Formation of a conidial body.

Fig. (*8*)—Hyphæ of **Colletotrichum falcatum,** *Went,* in a young state in a cell of a cane sent from Narail Jessore. The hyphæ were quite colourless. Mag. $\frac{240}{1}$.

Fig. (*9*)—Hyphæ in an older state, in a cell of a cane sent from Narail, Jessore. The hyphæ were coloured a sepia brown tint. Mag. $\frac{240}{1}$.

Fig. (*10*)—Longitudinal section of cane, attacked by **Dinoderus.** Contrast with Fig. 2. Nat. size.

Fig. (*11*)—**Dinoderus**—Mag. $\frac{4}{1}$.

Fig. (11) was drawn by one of the artists of the Indian Museum, by kind permission of Major Alcock, I.M.S.

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G. I. C. P. O.—No. 1202 R. & A.—9 7-1901.—2,230.—C. W. W.


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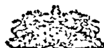
OXEN.

(CATTLE DISEASES.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. V, O. 590-94.*]

DISTOMATOSIS IN CATTLE AND BUFFALOES IN INDIA.

A Note by VETERINARY CAPTAIN H. T. PEASE, F.Z.S., *Principal, Panjab Veterinary College, Lahore.*



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A Note by VETERINARY CAPTAIN H. T. PEASE, F.Z.S., *Principal, Panjab Veterinary College, Lahore.*

DISCOVERY IN INDIA.

The occurrence of **Distomatosis** as a serious epidemic disease amongst the Cattle of India was brought to notice so long ago as 1895 in an article I contributed to the Veterinary Journal. I was first made acquainted with it owing to an investigation which was undertaken with a view to ascertain the cause of the great mortality which occurred amongst the Cattle in the vicinity of the Collair lake in the Godaveri District of Madras. Since this time, however, I have found it to be more or less prevalent, and in some cases very serious, all over the Panjab wherever low-lying swamps occur, and especially along the banks of the rivers. By the rivers great numbers of Cattle and Buffaloes are lost from it. In such country which is subject to periodical inundations, which gradually subside leaving marshy land producing a growth of coarse grasses and sedges, Distoma finds a congenial habitat.

Vernacular names.

Native names.—In Madras the disease is termed "*Iduga*" and in the Panjab "*Jhonk*" or "*Panilog,*" "*Gillhar*".

OUTBREAKS AT THE COLLAIR LAKE.

Notice of the Collair Outbreaks.—The Collair lake district may be taken as typical of the class of country most suitable for its occurrence and the description of the outbreaks may well illustrate the subject. The Collair lake is surrounded by the villages

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OXEN.	Distomatosis in Cattle and Buffaloes in India.

OUTBREAKS AT THE COLLAIR LAKE.

of Ellore, Bhumavaram, and Gudwada taluks. The fields on the border of the lake are inundated during the rainy season owing to surplus irrigation water flowing into it. The lake contains the greatest amount of water during the rains, *viz.* :—in the months of September and October, and this gradually evaporates from December to May during which latter month the lake contains the minimum quantity of water. The shores are at this season densely covered with decaying mosses, the water being black and muddy. Rice cultivation has been extended up to the borders of the lake, and the people are obliged to send their cattle during the cultivation season to the uplands to graze, and after the harvest bring them back to graze on the shores and in the bed of the lake from February until June. The Cattle when they are put on the lake to graze improve in condition and milk yield and this continues for some time afterwards, but is followed by gradual loss of condition. The people realize that Cattle fed on the grass grown on the stagnant water are pretty certain to contract the disease. There is a general complaint in every village that a great number of Cattle, especially buffaloes, die annually, and that they suffer much loss in consequence, each cultivator apparently losing five or six Oxen annually. This state of affairs is found in similar positions in the Panjab.

SYMPTOMS.

Most marked Symptoms.—The most marked symptoms of this disease are gradual emaciation, unhealthy appearance of the skin, watery condition of the mucous membranes, and what is more especially noticed by the people, the appearance of œdemata on the dewlap, and sometimes also in the sub-maxillary space and under the abdomen. The skin becomes dry and the animal hidebound. Digestion is deranged, rumination and the action of the bowels irregular, the animal sometimes being constipated and at others suffering from diarrhœa. These symptoms gradually increase in intensity, and diarrhœa becoming marked death supervenes from exhaustion at between two and four months after the first symptoms have been noticed.

Post-mortem appearances.—The following *post-mortem* appearances may be observed in the buffalo and ox. Body extremely emaciated, the skin hidebound and dry; dropsical effusions into the subcutaneous tissues, the fat replaced by a gelatinous-looking material. All the tissues are pale and flabby. Liver greatly enlarged, all ducts and gall bladder filled with large flukes. Over

100 have been removed from the gall bladder. The bile black in colour, duct dilated.

THE PARASITE.

The parasite.—The parasite causing the disease is Fasciola hepatica angusta. Considerable interest attaches to the parasite which causes this disease. Its occurrence has not previously been recorded in this country. It has, however, been described by Raillet in 1895 from specimens taken from Cattle slaughtered at St. Louis, Senegal. Blanchard thinks it identical with Fasciola gigantea of the giraffe. Laoss has described under the name of Fasciola egyptiaca, a parasite occurring in Bos taurus and Bos bubalus in Egypt which Blanchard considers identical with the fluke we are at present dealing with. The peculiar features of this fluke are its great length as compared with its breadth: it is a long and narrow and flat fluke. Raillet's specimens measured from 26 to 38 milimetres in length and were from 6 to 8 milimetres broad, or roughly from one to one and a half inches long and a quarter of an inch broad. All the specimens I have are well over an inch long and ⅛th broad. The parasites when freshly taken are of a flesh colour and semi-transparent. They present all the characters of Fasciola. The intestines are branched and ramified. The body tapers in front so as to form a cephalic prolongation at the end of which the mouth is situated. The acetabulum opens very close to this on the ventral surface; it is of fair size and salient, with a triangular orifice the base anterior: the body then rapidly gains its greatest breadth which gradually tapers towards the tail narrowing the inferior extremity being rounded. The integument is covered with small spines, especially on the ventral surface and in front. The genital pore is situated a little in front of the acetabulum, it often shows the ejaculatory canal evaginated in the form of a penis. The eggs which may easily be obtained by opening the uterus in front of the ventral opening are ovoid and relatively long. The shell is very thin, and one may often observe a small opercule and at the other a slight, more or less irregular elevation. The size of the eggs seems to vary from 143 to 150 μ. in length and 82 to 87 μ. in breadth. Altogether there is not much difficulty in distinguishing this worm owing to its great length and narrow breadth.

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(REPRINT FROM THE BENGAL BULLETIN, No. 6.)

BRASSICA SP.

(MUSTARD.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. I., B. 799-855.*]

ON THE SEEDS OF SOME SPECIES OF BRASSICA AND SINAPIS

WITH REFERENCE ESPECIALLY TO THOSE OF INDIA.

By DR. W. KINZEL, *of the Agricultural Station at Dahme, Brandenberg.*
[*Translated from 'Die Landwirtschaftlichen Versuchs-Stationen,' Vol. 52, pages 169-93.*]

Other PAPERS that may be consulted:

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" Thacker & Co, Ld, Bombay.

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THE AGRICULTURAL LEDGER.

1901—No. 7.

(REPRINT FROM THE BENGAL BULLETIN, No. 6.)

BRASSICA SPP.

(MUSTARD.)

[*Dictionary of Economic Products, Vol. I*, B. 799 855.]
Consult Agricultural Ledger No. 1 of 1898.

ON THE SEEDS OF SOME SPECIES OF BRASSICA AND SINAPIS WITH REFERENCE ESPECIALLY TO THOSE OF INDIA.

By DR. W. KINZEL, *of the Agricultural Station at Dahme, Brandenburg.*
[*Translated from 'Die Landwirtschaftlichen Versuchs-Stationen,' Vol. 52, pages 169-93.*]

INTRODUCTORY.

[The accompanying paper by Dr. W. Kinzel forms a fitting supplement to Major Prain's article on "Mustards Cultivated in Bengal" published in *The Agricultural Ledger*, No. 1 of 1898. Major Prain, in the above article, has classified in a botanical manner the various mustard plants known under the vernacular names of *Tori*, *Rai* and *Sarson*, and has completely revised the whole of the species and varieties of Brassica cultivated in Bengal. Dr. Kinzel, of the Agricultural Station at Dahme, was supplied with authentic samples of Indian mustard seeds, and he proceeded to make a microscopical and chemical examination of them in order to compare their properties with those cultivated in Europe. The special feature of Dr. Kinzel's important paper is the careful estimation of the mustard oil in all the samples submitted to him. The oil here referred to is not what is known in the bazars and used for domestic purposes in India, but the essential

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or volatile oil which is the pungent principle of the seed. The essential oil of mustard is a liquid composed of carbon, hydrogen, nitrogen and sulphur in definite proportions and known to chemists as allyl-thiocarbimide. Reports on the yield of the sulphuretted oil in mustard have been quoted in some publications and the results are disparaging to the Indian seed. But owing to improved methods of analysis devised by **Drs. Dirck, Schlicht and Forster,** it has been shown that there is not such a very wide difference in the pungency of commercial mustards.

Oil percentages.

In the Annual Report for 1893 of **Messrs. Schimmel & Co.,** Leipsig, the following percentages of mustard oil are quoted:—

Russian seed	·4—·5
Dutch "	·7—·8
Italian "	·6—·7
East Indian "	·6—·7
German "	·7

These conclusions are borne out by **Dr. Kinzel,** who shows that the average yield of Tori seed is 0·549, Rai seed 0·814, and Sarson seed 0·708. The translation of his paper follows.

Objections to use of Oil-cake exist.

The latest investigations on this subject seem to show that, at any rate under certain conditions, the use of mustard oil-cake is not altogether free from objection.* It is, therefore, important to devise some means, as far as possible accurate, yet at the same time easy to use, of recognising under the microscope the seeds of the various species of **Brassica** and **Sinapis** that yield mustard-oil. This is particularly necessary in the case of the principal Indian **Brassicas** that yield mustard-oil, and in that of the Russian "Sarepta" mustard.

Black mustard-seed is microscopically easily distinguished from all the species now to be considered. The only species that on casual examination approaches **Brassica nigra** in appearance is **Sinapis dissecta,** *Lag.*; in both these species the thin and readily rupturing upper layer of the palisade tissue is finely reticulated, and it is only with some practice that the two can be diagnosed. The transverse section of the testa is, however, quite different in these two, and, when this is obtainable, it provides an unfailing diagnostic character.†

The structure of the seed-coat indicates a possible diagnosis by it.

The statements of **O. Burchard,** of Hamburg,‡ show that however difficult it may usually be to obtain transverse sections from the

* Landwirt Versuchs-Station. Vol. 50 (1898), pp. 431-440.
† Journ. f. Landwirt. Vol 44 (1896), p 338.
‡ Journ. f Landwirt. Vol. 42 (1894), p. 125, vol. 44 (1896), p. 328.

residue of the mixed seeds imported direct from India, it is nevertheless very desirable that we should be able to distinguish with certainty from an accurate examination of their surface structure, the seed-coats of the various species.

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Any means of diagnosis to be seized on.

Therefore when a favourable opportunity offered itself, the author, in July 1897, addressed the Superintendent of the Royal Botanic Garden, Calcutta, in order to obtain the samples of seed that were desired. He was informed that at that very time 150 samples of seeds of the native Brassicas from every part of Bengal had been sent to the Royal Botanic Garden by the Director of Land Records and Agriculture for that Government, in order that the various species might be accurately determined with reference to their common vernacular names. *These seeds were sown at the Sibpur Experimental* Farm, near Calcutta, on October 22-23, 1896, and the plants were observed from their germination till they ripened seed (January-February 1897); when samples of the various kinds were sent to the agricultural station at Dahme, in order that the writer might investigate their microscopic and other differences. The proof sheets of a paper* on the results of this experimental cultivation along with 25 herbarium specimens of these cultivated Brassicas were also sent to the writer who was thus provided with ample material for the discrimination of the various species.

Dr. Kinzel procures authentic seed from India and from Russia.

At the same time Mr. Becker, a naturalist of Sarepta, sent freshly gathered seed of "Sarepta" mustard, grown in the Steppe of Sarepta, Government of Saratof, to enable the writer to determine if this plant (Brassica besseriana, *Andr*) is separable from the Indian forms of the B. juncea group.

With a view also to completing the Tables of Forster,† determinations of the mustard-oil and microscopic examination of the testa were made in the case of Sinapis chinensis, *Linn.*, Brassica japonica, *Sieb*, and B. pinnatifida, *Desf.*, which had been grown at Dahme in 1894, as well as of Sinapis dissecta, *Lag.*, cultivated there in 1898.

Space forbids more than a general reference to the contents of Major Prain's paper in *The Agricultural Ledger*§. The key to the

* *Agricultural Ledger*, 1898, No. I. A Note on the mustards cultivated in Bengal, by D. Prain.
† Landwirt. Versuchs-Station, Vol 50 (1898) pp. 421-423.
§ The Mustards cultivated in Bengal 1898, No. 1.

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species which it contains has already been reproduced in this Journal.* Among its botanical notes there is much that a monographer should find important; among the remarks on the vernacular (Sanskrit and Hindi) names there may be something to interest the linguist.

Major Prain remarks the confused nomenclature of the mustards.

The difficulties experienced by Major Prain in identifying the 150 samples of seeds, already alluded to, are sufficiently evident, and explain, moreover, how it happens that erroneously or inexactly named specimens so often reach those investigating this subject in Europe. The transposition, by a typographical error, of the vernacular names of *Rai* (Brassica juncea, *H. f. & T.*) and *Sarson* (Sinapis glauca, *Roxb.*) in Hooker and Thomson's treatise on Indian Cruciferæ† seems to have led to confusion in subsequent literature. And at a later date, too, *Tori* (S. dichotoma, *Roxb.*) and *Sarson* have been unwarrantably united, while comparatively unimportant forms of *Sarson* such as that with pendent fruits, Ulta Sarson (S. trilocularis, *Roxb.*) and that with 4 placentas (B. quadrivalis, *H. f. & T.*) have been separated as distinct species.

A literature with such confusions could afford little assistance. Major Prain put it into the background, remarking:—"The nice academic questions involved in deciding what constitutes a species, subspecies, or variety are fitly discussed in monographs of natural families. But in notes like the present, purely economic in scope, such refinements tend only to confusion. When the layman, in the course of business or duty, is brought face to face with two plants so dissimilar in appearance, mode of growth, time of ripening and method of cultivation and so completely wanting in anything of the nature of intermediate forms as Sarson and Tori are; and when on turning to a botanical work he finds it stated that they are the same thing or at most only different varieties of the same thing, he is apt to wonder at systematic botany."

He recognised that the only method promising to afford a definite knowledge of the races was to sow the seeds and to watch the plants from their germination till they ripened. The result showed that, so far as Bengal is concerned, only three kinds of Brassica are grown on a commercial scale, *viz.*:—

Species in Bengal and European equivalents.

(1) *Rai*: Brassica juncea, *H. f. & T.*, not grown in Europe but in India taking the place of B. nigra and B. alba which are not grown in India.;

* Landwirt. Versuchs-Station, Vol. 50, pp. 377-380.
† Journ. Linn. Soc., Vol. 5, pp. 169-170.

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(2) *Sarson*: Brassica campestris, *L., var.* Sarson, *Prain;* not grown in Europe; in India taking the place of B. campestris, *var.* oleifera and B. Rapa, *var.* oleifera, neither of which are grown in India.

(3) *Tori*: Brassica Napus, *L*, *var.* dichotoma, *Prain*; this latter appears to Major Prain to correspond to the summer Rape of Europe or to come very near that plant; in India it takes the place of the European B. praecox and B. Napus, *var.* oleifera.

It should be noted that the expression 'not grown in Europe' means not grown on a commercial scale. In our correspondence the only question left open was whether there is in Europe a species identical with B. juncea, *H.f. & T.* As the microscopic part of this paper will show, it seems certain that none of the species grown in Europe is the same as the Indian B. juncea. The cabbage mustard, B. rugosa, *Prain*, grown in India both as an oilseed and a vegetable, is cultivated in Europe, but only as a garden plant. This species its author was inclined to place in the B. juncea group; it differs, however, in the microscopic structure of its seeds. The Russian B. besseriana, *Andr.* (Sarepta mustard) and the Danish B. lanceolata, *Lange*, both closely resemble B. rugosa, *Prain*, so far as the structure of their seeds is concerned, but they can hardly be considered identical with it, for both are very easily distinguished from B. rugosa by the surface markings of the testa.

Reference must be made to what Major Prain says regarding the cultivation of the Indian mustards in a letter written with reference to the reciprocal cultivation of the species dealt with in this paper—the European ones at Calcutta, the Indian at Dahme. "The time for sowing mustard at Calcutta is from the middle to the end of October, so that it is not possible to sow your (Dahme) seeds this season, though I hope, by adopting the method you recommend, to keep the samples fresh till next year. It is, however, not easy to keep seeds of this kind in good condition during the rains. The native plan of preserving their seed is as follows:—When the mustard crop is harvested, the seed required for export, expression of oil and the like is thrashed out. A certain number of plants are kept, however, for next season's sowing. These are not thrashed; they are tied in loose bundles, and hung up in the smoky atmosphere of their houses. I imagine that the walls of the capsules permit all the air that is

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required for the respiration of the seeds to pass through, while at the same time they protect the seeds sufficiently against the deleterious influence of bacteria. At any rate native seeds kept in this way remain good and germinate freely at the proper season. The seeds kept by me from last year's crop are no longer in a germinable state.

"As all our mustards are cold-weather crops, they ought to correspond in their mode of growth with your various summer crops."

DESCRIPTION OF THE SEEDS.

I.—Indian Species.

INDIAN RAPE.

A.—Brassica Napus, *L., var.* dichotoma, *Prain. Tori, Indian Rape.*

Description.

A cold-weather crop of the Indian plains, a Himálayan spring crop Annual plants of relatively small size, branching freely, about 0·3—1·2 metre high, with slender spreading branches making a loose head 0·6—0·9 metre wide. Capsule including the beak 5—5·5 cm. long, beak 1·5 cm, 2-valved, seeds about 10 under each valve, light brown, finely punctuate, with greenish hilum and yellow cotyledons. The plant, usually an oilseed crop, is also grown in North Bengal and Sikkim as a vegetable, for which latter purpose the seeds are sown very thickly so that the plants may come up leafy and weak.

Seeds occasionally seen in oil-cake in Europe.

The seeds are only occasionally met with in Indian oil-cake at this place (Dahme) and almost always in small quantity. As compared with European Rape and Colza, the amount of mustard-oil the seeds contain appears very variable. As compared with the other species, the testa of the seed has remarkably narrow, very distinctly circular markings. The only species with circular markings almost as small is B. rugosa, *Prain*, which is at once diagnosed by its detachable epidermal layer. All the samples dealt with here have in transverse sections an *undetached* epidermal layer with narrow lumen, reversing the experience obtained by Burchard, who must have examined the seeds of quite another plant. This idea is confirmed by the fact that the seed-weight recorded by Burchard is much too high (*conf.* also Forster in *Landwirt. Versuchs-Stationen,* 1898, page 20) The transverse sections of the samples examined were, moreover, very uniform. As compared with the other species, the cells of the palisade-tissue have a very thin wall and consequently

Diagnosis by seed.

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INDIAN RAPE.

a clearly-defined wide lumen,* exactly as in **B. napus**, *L.*, the European rape. In transverse section they appear very blunt at the apex. The layer with colouring matter is very loose; the viscid cells are often in two layers; the thin-walled parenchyma is disposed in 3-4 layers.

Chemistry of seed.

(1) *Lutni*; from Chota Nagpur, district Hazaribagh. Seed-weight (air-dried seeds) average 2·723 mg.; water-free seeds 2·5 mg. Size of seed irregular. Mustard-oil 0·239 per cent.; in a second sample of *Lutni* from district Lohardaga 0·559 per cent. Moisture 8·21 per cent.

(2) *Bhunri*; from Bengal, district Hooghly. The circular markings in this kind were, on the whole, even narrower than in *Lutni*, and the cells of the palisade-tissue a good deal sharper, with conical lumen. The transverse section was of the same general character as that of *Lutni*. Seed-weight, air-dried seeds, average 2·003 mg.; water-free seeds 1·81 mg. Size of seed even less uniform than in *Lutni*. Mustard oil 0·848 per cent. Moisture 9·63 per cent.

INDIAN COLZA.

B.—**Brassica campestris**, *L.*, *var.* **Sarson**, *Prain.* *Sarson, Indian Colza.*

The much-involved nomenclature of this species should be studied in Major Prain's article. From what he says in *The Agricultural Ledger* and has stated in his letters to the writer, it is clear that it would be advisable to abandon the use of the term "glauca" used in the Kew Bulletin (1894), because the species there intended is not clearly limited. The "glauca" of Wittmack, Guzerat Rape is the same plant, but besides this "glauca," Sarson includes both **B. trilocularis** and **B. quadrivalvis**, while it excludes **B. glauca**, *Royle*, which is a synonym of **B. dichotoma**. Some passages relative to this much-misunderstood species must be quoted from *The Agricultural Ledger* article before proceeding to describe the seeds, but for details both as regards this and the following one, and as regards the present species for details as to the chambering of the capsule in particular, direct reference to that article is necessary.

Description.

Sarson is a crop of the cold weather, of slender habit, about 1·2—1·5 metre high, rather rigid and unbranched or branching into a pyramidal head 0·3—0·5 metre wide. The capsules are variable in form, and provide characters that help in classifying the races. As a rule, they are about 1 cm. wide, broader than thick, 2-valved and 2-celled;

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have to be considered. **Sesamum** has also sometimes been met with, and frequently small quantities of Linseed and Wheat occur among Indian Mustard seeds. Seeds of some other weeds that have not yet been determined are also met with, but less frequently.

II.—Extra Indian Species.

BRASSICA BESSERIANA.

D.—Brassica besseriana, *Andr. Russian "Sarepta" Mustard.*

Whether this plant is grown on a large scale anywhere beyond the limits of South Russia must for the moment be considered uncertain.*

Description. The freshly harvested seeds sent from Sarepta are mostly of roundish shape with some longish seeds intermixed, and of a brown colour clearer than that of **B. Rapa**; size of seed rather irregular; seed weight (air-dried seed) 2·047 mg., water-free seeds, 1·867 mg.

Chemistry. Mustard-oil, 0·891 per cent. and 0·918 per cent., mean 0·905 per cent.; moisture, 8·77 per cent.

Diagnosis. The structure of the seeds, as compared with the explicit statements of Burchard,† shows a very important difference which is not easy to explain, since, having regard to the source of his seeds, a mistake seems hardly possible.

The mucous epidermis in particular shows in transverse section a very clearly separating cellular structure like that of **B. lanceolata**, *Lange*, a plant which, according to a recent author, is identical with the Russian species ‡; the figure that Burchard gives of **B. lanceolata** would pass exactly for one of **B. besseriana**. The remaining details of the structure in transverse section will be seen from the figure.

The structure in surface preparation shows the inequality in length of the cells of the palisade tissue by very distinct circular markings. The lumina of the palisade cells often appear of three cornered or small nearly rounded form in the surface preparation.

The microscopic characters of this species are so peculiar that it is hardly possible for it to be confused with any of the other species described here.

BRASSICA LANCEOLATA

E.—Brassica lanceolata, *Lange.*

A Danish plant. With reference to what has just been said regarding **B. besseriana** it may be mentioned that all the samples

* Index Kewensis; "Rossia, Asia temp."
† Journ. f. Landwirt (1894 and 1896), ll. cc.
‡ *Ascherson und Gräbner, Flor. d. Nordost deutsche Flachlandes*, 1898, p. 361.

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of B. lanceolata that were examined showed the structure described by Burchard with the exception of the seeds of a specimen preserved in the Royal Botanic Museum, Berlin, ticketed "ca Haunıam." The seeds of another plant, also preserved there (cult. in Hort. Berol., 1876), show nevertheless the cell-separation evident in the samples available at Dahme. Unfortunately there was not sufficient material available for the estimation of the percentage of mustard-oil. BRASSICA LANCEOLATA.

F.—Sinapis dissecta, *Lag.* (Brassica, dissecta, *Boiss.*) SINAPIS DISSECTA.

The seeds of this species which is grown in South Russia and is very closely related to B. alba are often met with as an adulterant of Russian linseed and of Russian linseed oil-cake, occasionally along with those of B. besseriana. It is often met with, too, in some quantity in rape seed oil-cake of Russian origin. An accurate account of the seeds is given by Burchard.*

The structure of the testa appears subject to small variations. At any rate, the angles of the thick cell-walls were usually found to be less evidently collenchymatous than in white mustard, though now and again corresponding to the figure given by Burchard. The thick cell-wall itself was usually one-layered and tighter—less corrugated—than is evident from Burchard's figure—

The percentage of mustard-oil, 0·049 per cent., corresponds with that of the allied B. alba.

G.—Brassica japonica, *Sieb.* (B. nigra *var.* japonica *Sieb*) BRASSICA JAPONICA.

This species is closely allied to, and has a microscopic structure very like that of B. nigra. A drawing and an account of the seeds will be found in Burchard's paper (l. c. 1894). The name used by him may, however, lead to confusion, for Sinapis japonica, *Thunb., is a synonym of B. juncea, H. f. & T.*

The percentage of mustard-oil in seed grown at Dahme in 1894 and kept in store for four years was 1·199 per cent. as against 1·68 per cent. in freshly-gathered seed.† Percentage of mustard oil; and loss during storage.

H.—Sinapis Chinensis, *L.* (*Syn.* Br. juncea, *H. f. & T.*) SINAPIS CHINENSIS.

For a description of the seeds consult Burchard (1894) l. c. Seed grown at Dahme in 1894 yielded at the end of 1898, 0·926 per cent. of mustard-oil.

*Journ. fur Landwirt. (189?) l. c.
† Landwirt. Versuchs-Station, Vol. 5?, p. 593.

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BRASSICA PINNATIFIDA.

I.—Brassica pinnatifida, *Desf.*

A native of Spain and North Africa. The mucous epidermis is not separable. The percentage of mustard-oil in four years old seed grown at Dahme in 1894, was 0·879 per cent.

In order to examine their structure by surface preparations, the seed-coats were treated with 1·25 per cent. H_2SO_4 and afterwards with 1·25 per cent. NaHO, each for two hours at 100° C., and then for another half hour with ether. To obtain cross-section the seeds were embedded in paraffin, the section being washed in ether to remove any paraffin and afterwards heated with 5 per cent. NaHO for a short time under the cover glass.

In making the drawings Abbe's Camera lucida was used. The enlargements were obtained by employing No. 5 eye-piece with object glasses B and D of Zeiss' system. The distance of the drawing from the centre of the reflector being 175 cm., the enlargement obtained are thus of 80 and 225 diameters respectively.

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the three following receivers all charged with an alkaline solution of permanganate :—

(1) An Erlenmeyer's flask of 500 cc. capacity with a doubly perforated India-rubber stopper through which the long tube passed to the bottom of the flask ;

(2) then a Will-Vallentrapp's globe one shank of which, bent at right angles, was directly connected with the India-rubber stopper of the Erlenmeyer; finally

(3) (attached by rubber-tube connection) a third Erlenmeyer's flask with again a doubly perforated India-rubber stopper for the accommodation of a glass discharge-tube passing to the bottom of the flask and of an unstoppered glass safety ube about 1 cm. long. The two (sulphur-free) rubber e connections must be so applied as to come as little ossible in contact with the steam or the liquid; they re to be frequently renewed.

eceivers were charged with 128 cc. of an alkaline tion, (1) with 100 cc., (2) with 18 cc., and (3) with . The composition of the permanganate solution was ,000 cc. of 5 per cent. permanganate and 28 cc. of 12 per ce), the latter prepared from sulphuric acid-free Na_2O obtained ct from Na.

Chemical manipulation.

To obtain an analysis of rape seed cake 15 grammes of powdered cake and 4 grammes of white mustard were placed in the mustard-pulp flask, and when 150 cc. of water and 0·25 gramme of tartaric acid had been added, the apparatus was ready.

The flame under the steam-flask should be lit at such a time as will admit of the steam entering the mustard-pulp flask after the mustard has been digesting for half an hour in the tartaric acid solution ; by thereafter heating the mustard-pulp flask with a gentle flame, 200 cc. will be distilled over into the receivers in an hour and a half. During this distillation the safety stop-cock on the steam-flash remained shut, and was only opened when there was a risk of regurgitation of the permanganate solution from the receivers into the mustard-pulp. Under ordinary circumstances this risk hardly exists. Care need only be taken that the two flames are gently increased while the distillation is going on. If this be done, the very violent regurgitation which is apt to take place from the Will's receiver is

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ESTIMATION OF MUSTARD-OIL.

MUSTARD-OIL.

The collections of seeds at the writer's disposal afforded so excellent an opportunity of arriving at a closer estimate of the amount of myronic acid present in authentically determined Indian species of Brassica that it was essential to keep this particularly in view as an object of his research. In order to estimate the mustard-oil, the author employed, because of its convenience, the method of Darks as modified by Schlicht, in preference to that of Forster which is generally used at Dahme, retaining, however, Forster's steam distillation. If the method in question be carefully conducted, the results of the estimation should never be substantially inaccurate.

Apparatus for estimation.

The apparatus used consisted of a flask of 500 cc. capacity, with a glass safety tube provided with a stopcock and a glass steam tube passing to the bottom of an Erlenmeyer's flask, also of 500 cc. capacity, which contained the mustard pulp. So far the apparatus was precisely that of Forster, the special glass top-piece of the mustard pulp flask included.

From this top-piece the mustard-oil vapour passed, without being cooled (Rubber-tube connection) through a glass tube 6 cm. wide and 70 cm. long bent downwards at nearly a right angle, into

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Necessary correction for loss, to be made in the estimation.

To effect this, weighed quantities of dried K_2SO_4, corresponding to the quantity of permangate-alkali used for the reduction, were added, and the H_2SO_4 was estimated exactly as in the mustard-oil estimation, in 400 cc. of filtrate. In two similar analyses there were obtained from 0·2539 gramme K_2SO_4 (in 500 cc.) from 400 cc. filtrate, 0·2539 gramme and 0·2641 gramme $BaSO_4$, an average of 0·2675 gramme in place of 0·27184 gramme; difference 0·00434 gramme. Again from 0·00939 gramme K_2SO_4, according to the above proportions, 0·00648 $BaSO_4$, instead of 0·010; difference 0·00352 gramme. Finally, from 0·3869 K_2SO_4 from two analyses of four-fifths the quantity, 0·4117 and 0·4133 gramme $BaSO_4$, = an average of 0·4125 gramme instead of 0·4142 gramme; difference 0·0017 gramme. The mean of these differences gives for 400 cc. of the alkaline liquid used, a loss of 0·00319 gramme $BaSO_4$ which has to be added to the quantity of Baryta obtained from the mustard.

The accuracy of the process checked.

It was now desirable to add to these preliminary researches a check on the accuracy of the operations described. For this purpose a Sarson cake was used that had already yielded by Forster's method, with the use of K I, $Hg I_2$, 1·14 per cent. mustard-oil.

When 10 grammes of the same average sample were used, the permanganate method indicated 1·127 per cent. mustard-oil. Two analyses of another average sample of the same cake gave, when 25 grammes (making a thicker pulp) were used, 1·097 per cent. mustard-oil, and when 10 grammes were used 1·18 per cent. mustard-oil.

Again, a rape seed cake with, according to Forster's method, 0·552 per cent. mustard-oil was twice analysed by the permanganate method; results, 0·558 per cent. and 0·566 per cent. mustard-oil. Thus even with the discontinuance of the described modifications, the utility of the permanganate method was demonstrated.

It was ascertained from a further analysis that the white mustard employed contained no myronic acid.

Heating the flour increases the yield.

Previous researches by Professor R. Ulbricht as well as by A. Schuster and Dr. Mecke had shown that heating the flour increased the yield of mustard-oil.* On this account the finely powdered seeds were placed before distillation in the dry mustard pulp flask and heated for half-an-hour to 70° by placing a water-bath below it. The connection with the receivers in the meantime was left open,

* Landwirt. Versuchs-Station, Vol. 52 (1898), p. 425.

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G. I. C. P. O.—No. 730 R. & A. D.—29-6-1901.—2,230—C. M. W.

MUSTARD-OIL.

To effect this, weighed quantities of dried K_2SO_4, corresponding to the quantity of permangate-alkali used for the reduction, were added, and the H_2SO_4 was estimated exactly as in the mustard-oil estimation, in 400 cc. of filtrate. In two similar analyses there were obtained from 0·2539 gramme K_2SO_4 (in 500 cc.) from 400 cc. filtrate, 0·2539 gramme and 0·2641 gramme $BaSO_4$, an average of 0·2675 gramme in place of 0·27184 gramme; difference 0·00434 gramme. Again from 0·00939 gramme K_2SO_4, according to the above proportions, 0·00648 $BaSO_4$, instead of 0·010; difference 0·00352 gramme. Finally, from 0·3869 K_2SO_4 from two analyses of four-fifths the quantity, 0·4117 and 0·4133 gramme $BaSO_4$, = an average of 0·4125 gramme instead of 0·4142 gramme; difference 0·0017 gramme. The mean of these differences gives for 400 cc of the alkaline liquid used, a loss of 0·00319 gramme $BaSO_4$ which has to be added to the quantity of Baryta obtained from the mustard. Necessary correction for loss, to be made in the estimation.

It was now desirable to add to these preliminary researches a check on the accuracy of the operations described. For this purpose a Sarson cake was used that had already yielded by Forster's method, with the use of K I, Hg I_2, 1·14 per cent. mustard-oil. The accuracy of the process checked.

When 10 grammes of the same average sample were used, the permanganate method indicated 1·127 per cent. mustard-oil. Two analyses of another average sample of the same cake gave, when 25 grammes (making a thicker pulp) were used, 1·097 per cent. mustard-oil, and when 10 grammes were used 1·18 per cent. mustard-oil.

Again, a rape seed cake with, according to Forster's method, 0·552 per cent. mustard-oil was twice analysed by the permanganate method; results, 0·558 per cent. and 0·566 per cent. mustard-oil. Thus even with the discontinuance of the described modifications, the utility of the permanganate method was demonstrated.

It was ascertained from a further analysis that the white mustard employed contained no myronic acid.

Previous researches by Professor R. Ulbricht as well as by A. Schuster and Dr. Mecke had shown that heating the flour increased the yield of mustard-oil.* On this account the finely powdered seeds were placed before distillation in the dry mustard pulp flask and heated for half-an-hour to 70° by placing a water-bath below it. The connection with the receivers in the meantime was left open, Heating the flour increases the yield.

* Landwirt. Versuchs-Station, Vol. 5› (18?8), p. 4?6.

B. 799-855.

BRASSICA Spp.

On the Seeds of Some Species of Brassica and Sinapis

MUSTARD OIL.

but the connecting tube between the mustard flask and the steam-flask closed by a clamp. At the end of the half-hour the tartaric acid solution was added through this latter connecting tube and the connection with the steam-flask restored. Then after opening the safety tube removing the water-bath, and adding the white mustard by means of a short stalked funnel through the glass top-piece of the mustard-pulp flask, the distillation described above was set agoing.

The seeds used for analysis were carefully cleared of seeds of weeds and of chaff and ground quickly in order, if possible, to avoid any loss of moisture. As a rule, 15 grammes of powdered seed were used for analysis; the exceptions were Sarepta mustard of which 16 grammes were taken; and the Rai from Jessore of which 10 grammes were employed, the first analysis of this having proved a failure.

Tables giving result of Analysis.

In the subjoined tables the numbers given are those sent from Calcutta with the corresponding Indian samples.

Results of Estimations.

n. Amount of mustard oil.

Number.	Name of mustard.	Source	Mustard-oil per cent.
1	2	3	4
	Brassica dichotoma, *Pr.* (*Tori*).		
1+15	Lutni	Hazaribagh	0·239
12	Do	Ditto	0·559
16+20	Bhunri	Hooghly	0·848
		Average	0·549
	Brassica juncea, *H f. & T* (*Rai*).		
3+11	[illegible]	[illegible]	1·059
13+32	[illegible]	[illegible]	0·572
4+14	[illegible]	[illegible]	0·790
18	[illegible]	[illegible]	0·683
24	[illegible]	[illegible]	0·924
9+36	[illegible]	Shahabad	0·854
		Average	0·814

B. 799-855.

with Reference especially to those of India. (*W. Kinzel*)

BRASSICA spp.

MUSTARD-OIL.

Results of Estimations—concld.

Number.	Name of mustard.	Source	Mustard-oil per cent.
1	2	3	4
	Brassica Sarson, *Pr.* (*Sarson*).		
2	Seti Sarisha . . .	Rangpur . . .	0·680
6+17	Piarki Tori . . .	Shahabad . . .	0·747
27	Piarka Tora . . .	Ditto . . .	0·794
8+35	Jauda Sarson . .	Ditto . . .	0·640
10+23	Makhan Dhaná Sarisha .	Backergunge . . .	0·642
25+29	Ulti Sarson . . .	Shahabad . . .	0·875
21+22	Ditto . . .	Purnea	0·807
19+26	Natua Sarson . . .	Shahabad . . .	0·626
30+34	Lalka Tora . . .	Ditto . . .	0·564
		Average .	0·708
7+28	B. rugosa, *Pr.* . .	Bengal (Kalimpong) .	0·826
		Mean of the 19 Indian kinds	0·731
	B. Besseriana, *Andr.* .	Sarepta, Government of Saratof	0·918 0·891
	[illegible]	[illegible]	[illegible]

b. Amount of moisture.

Weight of seed and percentage of moisture.

Number.	Name.	Weight of air-dry seeds	Weight of seeds dried at 105 degree.	Number of weighed seeds.	Percentage of moisture
1	2	3	4	5	6
		Mg.	Mg.		
12	Lutni . . .	2·7232	2·4097	1,889	8·21
16	Bhunri . .	2·0029	1·8096	2,148	9·63
3	Jhuni . . .	2·1359	1·9046	1,973	10·83
6	Lalki Tori . .	2·7879	2·5094	1,550	9·90
13	Kazli Sarisha .	2·8258	2·5823	1,534	8·40
2	Seti Sarisha .	3·6758	3·3793	1,070	8·07
6	Piarki Tori . .	5·0682	4·6632	895	7·98
27	Piarka Tora .	6·5060	6·0194	970	7·48
8	Jauda Sarson .	3·0773	2·8375	1,429	7·75
19	Natua Sarson .	3·1243	2·8694	1,310	8·15
25	Ulti Sarson . .	4·5808	4·2018	1,101	8·45
30	Lalka Tora .	8·1789	7·5016	636	8·29
7	B. rugosa . .	1·3330	1·1829	3,082	9·13
	B. Besseriana .	2·0466	1·8671	4,000	8·27

B. 799-855.

KEY TO PLATES.

and B. quadrivalvis, *H. f. & T.*). Transverse section of testa of Seti Sarisha from Rangpur, Nilphamari. Epidermal layer not detachable. Palishade-cells somewhat narrower, but in other respects like No. 1 and No. 2.

4. Brassica juncea, *H. f. & T.* (Sinapis ramosa, *Roxb.*) Transverse section of testa of Jhuni from Hooghly—(1) Soft Parenchyma. (2) Glutinous cells. (3) Colouring matter layer, hardly different from (4) Palisade tissue, the cells usually tolerably acute. (5) Epidermal layer, undetachable.

4. (*a*) Tangential view of the preceding. Rings very strongly marked and even in colourless fragments visible as deep grey shadows. The points marked "a" in this and the preceding figure correspond.

5. Brassica rugosa, *Prain.* Transverse section of testa—(1) Thin-walled parenchyma, 2-3-layered. (2) Glutinous cells. (3) Colouring matter layer, darker than (4) Palisade tissue, thin, connected with threadlets as (more distinctly in B. nigra.) (5) Epidermal layer, detachable.

5.(*a*) Tangential view of the preceding. Rings very distinct, smaller than in B. juncea, rarely, in clearer fragments nearly as large, but then with finer ridges as in the left-hand figure.

PLATE II.

6. Brassica Besseriana, *Andr.* Sarepta mustard. Transverse section of testa—(1)—(5), indications the same as in the figures on Plate I. Epidermal layer clearly detachable.

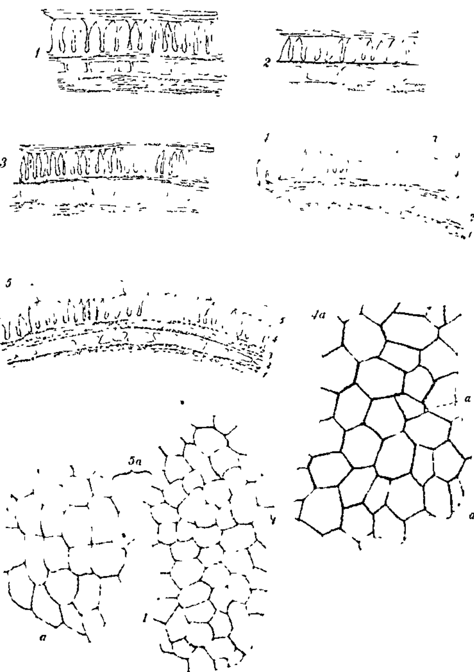
6. (*a*) Tangential view of the preceding showing the very distinct circular markings.

7. Brassica Napus, *L., var.* dichotoma, *Prain.* (Sinapis dichotoma, *Roxb.*) Transverse section of testa of Bhunri from Hooghly. (1)—(5) indications as in other figures. (*b*) Palisade tissue of Lutni from Hazaribagh.

7. (*a*) Tangential view of Bhunri from Hooghly.

7. (*b*) Tangential view of Lutni from Hazaribagh.

G. I. C. P. O.—No. 730 R. & A. D.—29-6-1901.—2,230—C. M. W.



[illegible] del. [illegible] lith.

SEEDS OF BRASSICA

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page

THE

AGRICULTURAL LEDGER.

1901—No. 8.

ARECA CATECHU, *Linn.*

(BETEL-NUT.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. I., A. 1294-1328.*]

A PLAGUE IN THE BETEL-NUT PALMS

AND

DESTRUCTION OF THE TISSUES BY WHAT APPEARS TO BE A FORM OF TYLOSES.

Report on a Tour in the Khulna, Backerganj and Noakhali Districts of Eastern Bengal. By GEORGE WATT, ESQ., M.B., C.M., C.I.E., etc., *Reporter on Economic Products to the Government of India*



CALCUTTA:
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1901.

(Crop Disease and Pest Series, No. 6.)

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1901

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(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers;

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept;

(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products to officials or other persons interested therein;

(4) To secure a connection between all papers of interest published on subjects relating to economic products and the official Dictionary of Economic Products With this object the information published in these Ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.

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All papers published will be paged, irrespective of subjects, into an annual volume.

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At the end of the year a printed index and title page will be issued, for the annual volume, and after a period of, say, five years an index and title page will be issued for each series It has been found that many persons subscribe for a certain series only, and do not care to receive the others The new arrangement, while permitting of the formation of an annual volume will at the same time retain the serial classification

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THE

ICULTURAL LEDGER

1901—No. 8.

ARECA Catechu.	A Plague in the

BETEL-NUT PALM DISEASE.

2. I examined the specimen as carefully as possible and may as well record here my observations and action, since these have a bearing on my subsequent investigations. The specimen was the top 4 or 5 feet of a betel-nut palm (perhaps 20 years old, the stem being about four inches in diameter), with its usual crown of leaves. Externally the plant looked fairly healthy. The upper portion of the stem was green, and though one or two of the leaves were broken and withered they were not more so than might have arisen from the plant having been cut down and handled somewhat roughly (and unavoidably so) during a journey by boat and rail of some two or three days' duration. The lower end of the stem was, however, decomposed and maggot infested. A number of small black beetles also escaped from the stump. This led me to slit the stem up lengthwise, when it was seen the maggots were confined to a few inches of the lower extremity that had very possibly got decomposed since the tree had been felled. The white starch-like granular structure of the stem with its fibrovascular bands looked otherwise quite healthy. There were no stains, no unhealthy patches, such as might have been expected through the presence of some parasite.

Maggot Infested Stem.

3. *External Manifestations of the Presence of Fungi.*—I then examined the epidermis of the green portion of the stem, of the leaf sheaths and of the leaves themselves to see if there were any indications of a parasitic fungus. In this I failed absolutely. The withered leaves were, however, attacked by a black mould, the mycelia of which had decomposed the cellular tissue and reduced the leaf-stalks to a mass of fibres in a rotten condition. I satisfied myself that this was a purely saprophytic action and could be in no way connected with the disease of the palms.

No Fungus Visible.

4. *Rotten and Maggot Infested Buds.*—I then slit the leaf sheaths open and was much surprised to find in every case the contained buds in an advanced state of decomposition and maggot infested. They also emitted a most offensive smell. But I was not a little surprised to find that the maggots were apparently identical with those seen in the rotten stump of the stem. I examined the stump again with the greatest care in order to see if, by any chance, the tree could have been felled purposely through a diseased portion. As this seemed unlikely but rather that the stem had decomposed and been maggot infested since having been cut down, the invasion of the buds and the stump with what appeared the same species of

Maggot Infested Buds

1294-1328.

insect led me to infer that in both cases very possibly the maggots had appeared subsequent to the death of the structures concerned, and were not the cause of death. BETEL-NUT PALM DISEASE.

5. I further noted that the base of the terminal bud near its union with the stem had also begun to decompose and to become maggot infested, while the two leaves partially expanded from it still remained quite green and stood erect. Major Alcock, I.M.S. (Superintendent of the Indian Museum), chanced to call on me while I was engaged with this examination; I accordingly asked him to be good enough to look at the maggots and to favour me with his opinion on them. He took away certain portions that were infested, and undertook to ascertain what the insects were by breeding them into their mature state. In his reply, dated 18th April, Major Alcock reported that "three different kinds of Dipterous insects, names unknown, have been bred from the piece of the stem of betel-nut palm." Although this is anticipating the sequence of events somewhat, I may say that I have been led subsequently to infer from the multiplicity of the insects found in the decomposing stems and buds that these could not be the cause of a specific disease to the trees, but rather a consequence of that disease. *Maggot Infested Buds.*

6. *Vessels of Diseased Tissue filled with Nucleated Cells.*—As I had failed to detect by means of a lens and low power microscope any external fungus, I took the liberty to send a few of the decomposed buds and their embracing leaf sheaths to Colonel D. D. Cunningham, C.I.E., I.M.S., for examination. Nucleated Cells within the Vessels. *Conf. with para. 14.*

There was unfortunately at that time no microscope in the office of Reporter on Economic Products, and my private one having been injured during a recent tour of exploration in Assam, I was unable to examine the tissue of the diseased parts. Dr. Cunningham very obligingly complied with my request and his letter of the 31st March confirmed the general impressions I had formed. He then wrote: "I have examined the specimens of Areca blight, and must confess they are a puzzle to me. There is not a trace of any ordinary fungal disease about them, but at the same time the vessels and ducts present very curious appearances being in many cases absolutely plugged with masses of relatively large very delicate nucleated cells. I am unfortunately too ignorant of the histology of palms to know how far this may be taken as a pathological phenomenon, but I have asked Dr. King to let me have healthy specimens for

AREC A Catechu.

A Plague in the

BETEL-NUT PALM DISEASE.

comparison. In the meantime and on the supposition that the condition is a pathological one, the only thing which the appearances possibly suggest is that the disease is of a **Mycetozoa** origin!"

Position of the Buds.

7. ***Further Particulars Regarding the Buds.***—By my letter No. 932 of the 27th March, I informed the Director of the Department of Land Records and Agriculture of the above action, I called for further material, and asked that attention might be directed to discover whether the disease invariably proceeded from the buds contained within the leaf sheaths. I may explain that the leaf sheaths are often 18 inches to 2 feet long, and that they unite around the stem, each forming a closely adhering tube, within which, and right at the bottom, the flowering buds are found. As these buds enlarge the sheaths are split open, a bulging being formed for some days before the sheath ruptures. I would explain also that in the specimen supplied to me on the 20th March, the buds were large triangular bodies from 2 to 3 inches long and nearly as broad and placed right at the base of the sheaths. But in every case, notwithstanding their being so carefully protected they had turned brown, and what was remarkable those in the higher and more tightly fitting leaf sheaths were, if anything, in a more advanced state of decay than the lower and outer and partly expanded buds. In man[y] ... also the decomposition was seen to have extended to the le[af] ...[shea]ths themselves, large patches of the inner surfaces of which had ... to a more rusty brown, it is true, than the putrid bud[s] ... [cle]arly in an unhealthy state. There were, howeve[r] ... patches no manifestations of the external fru[ctification] ... parasitic fungus. (*Conf. with para. 36.*)

8. ***Mr. N. G. Mukharji's Repor[t].***— ... the Director's letter No. 625 A., dated the 27th ... [receiv]ed a copy of Mr. Mukharji's report of his investigatio[n] ... [distri]cts badly affected by the disease. This, while giving mu[ch] ... [interesti]ng information as to the extent of the malady, its distribution ... appearance and particulars of a former, and presumedly similar, outbreak 20 years ago, proceeded to attribute the disease to a fungus that he identified as very possibly a species of **Pythium**. In support of this view of the case he forwarded certain microscopic slides showing various stages of that fungus. These I at once examined with a low power microscope, but, as I failed absolutely to find anything to ... Mr. Mukharji's views, I sent them to Colonel. D. D. C...

[Attribu]ted to [a sp]ecies [of Pyt]hium.

BETEL NUT PALM DISEASE.

I.M.S., for his opinion. He was good enough to invite me to come to his laboratory to see Mr. Mukharji's slides, and at the same time to examine other specimens which he had himself prepared from the material sent to him. We examined the slides with the greatest care, but as Dr. Cunningham had previously written me, there was not a suggestion of a Pythium or Peronospora to be found. What deceived Mr. Mukharji, apparently, was a somewhat curious Alga (Cephaleuros mycoidea) which is frequently prevalent on the leaves. It is, therefore, hardly necessary to enlarge upon the issues raised by Mr. Mukharji's report.

Numerous Saprophytic Fungi.

No sooner have the tissues of the leaf, bud, or stem, been killed than they become a perfect botanic garden of saprophytic fungi and harbour also countless forms of insect life. The temptation is, therefore, very great to divert attention from cause to effect and to wander through and get lost in the unexplored field of fungal forms to be found on the decomposing structures.

BURNING AND FUNGICIDES.

9. I take the opportunity of mentioning here that I was fortunate in obtaining on loan, from the Mathematical Instrument Department, a microscope of sufficient power to enable me to examine the second consignment of samples sent to this office. I thought it as well, however, to advance no very definite opinions, and to leave Mr. Mukharji to be possibly correct until I had had the opportunity of more fully establishing my own views. Accordingly my reply No. 1205—222, dated the 29th April, stated that I had obtained indications that pointed in the direction of the opinion that the disease was possibly of fungal origin. I ventured, however, to differ with Mr. Mukharji that, in recommending a chemical treatment to be pursued, it did not matter very much, for practical purposes, which mildew it is that causes the destruction. And here I would add that it is essential before any such treatment can be recommended that we know the life-history of the organism causing the disease. I, however, concluded my remarks on this subject (in the letter above quoted) by saying that I entirely concurred with Mr. Mukharji in recommending burning as perhaps the most certain way of checking the spread of the disease. Once a palm is invaded with this mysterious disease death seems very nearly universally to follow.

Disease of Fungoid Origin.

ARECA Catechu.	A Plague in the

BETEL-NUT PALM DISEASE.

From the copy of a correspondence on this subject (furnished to me) that has passed between the Director of Agriculture and Colonel Sir George King, K.C.I.E., I.M.S., Superintendent of the Royal Botanic Gardens, I learn that he also has arrived at the opinion that destruction by fire is the only likely method of coping with the disease, until such time as we have learned the life-history of the organism that is concerned in the death of the palms.

10. ***Fungicides.***—So far as I have been able to discover, regarding the structure that is at least in fairly constant association with the destruction of the trees, no chemical treatment is ever likely to be of avail. The growth to which I allude lives within the tissue of the palm and apparently comes to the surface only (if ever) when the palm has been killed. To *syringe affected trees with poisons* can be of no possible advantage, either to save the individual from the certain death that is rapidly overtaking it or to check the spread of the malady. If my observations be confirmed by future investigators, that the organism seen by me within the tissue of affected palms, is the actual or even chief cause in their destruction, it might be said that it would very possibly be more effectual to pour the fungicide into the ground around the roots than to spray the domes of leaves and terminal buds. A system of spraying young trees might possibly be of advantage in killing the germs of destruction, before they have inoculated new hosts (assuming that such inoculation took place which I think not), but the course proposed would be impracticable, since it would mean the syringing of a forest of palms, each 30 or 40 feet in height. So again, allowing that it can be demonstrated that fungicides actually do arrest the disease, organic lesions of so serious a nature have been effected before the external symptoms of disease have appeared that I should very much doubt the advisability of saving such trees.

MY DEPUTATION TO THE AFFECTED DISTRICTS AND PLACES VISITED.

Deputation to Report no Affected Districts.

11. In reply to my letter of the 29th April 1896 I received telegraphic instructions to visit the districts most severely affected, and to thus conduct a personal enquiry, provided this could be accomplished within a period not exceeding one month. Mr. N. G. Mukharji was deputed by the Bengal Government to accompany me, and joined me at Barisal on Sunday, the 17th May. I availed myself of a

BETEL-NUT PALM DISEASE.

Localities Visited.

very generous offer made me by Messrs. Hoare, Miller & Co. to travel in their steamer, the *Alokashi*, that was to sail on the 14th direct from Calcutta to Barisal. Although this occupied the greater part of two days longer than the route by train to Khulna and steamer to Barisal, I was enabled to study the Sunderbands, and as I could stop the steamer as found necessary, I had several opportunities of studying the disease in more southern parts of the Khulna and Backerganj districts than I would otherwise have had. At Morellganj we were joined by Mr. W. A. Lee of the firm of Messrs. Hoare, Miller & Co.—a gentleman who has devoted much of his leisure hours to microscopic studies, and who took accordingly the keenest interest in the investigations into the cause of the betel-nut disease. And I desire to take this opportunity of reporting that, through Mr. Lee's active co-operation, I was enabled to accomplish the work entrusted to me more rapidly and thoroughly than I could otherwise have done, since he practically placed at my disposal the resources of the Bengal Central Flotilla Company, and at the same time assisted very greatly in the numerous microscopic examinations that had to be made.

12. At Barisal I consulted the Magistrate and Collector, Mr. Beatson Bell, who, having then only just joined the district, regretted his inability to afford me any particulars. He agreed, however, with Mr. Lee and Mr. Mukharji that I had better in the first instance visit the Mendiganj sub-division, where the disease was said to be very bad. On two occasions I drove through the suburbs of Barisal in order to see the extent to which the blight prevailed in the sadar station. I was surprised to find that the betel-nut palms in and around Barisal itself were not affected.

13. Mr. Lee having placed the *Alokashi* at my disposal, we sailed from Barisal at daybreak on the 18th and anchored at Patharhat at 7 A.M. A visit was at once made to Badarpur, where the disease was known to prevail. A large number of trees were brought on board and the day spent in their examination. In the afternoon a visit was next paid to Sonamukhi, where further particulars and specimens were procured. At daybreak on the morning of the 19th an exploration was made to the more distant village of Lashkarpur—a village with a very extensive betel-nut cultivation, and where it was estimated something like 90 per cent of the trees had been killed. At 12 noon we returned to the *Alokashi*, which at once returned to Barisal.

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BETEL-NUT PALM DISEASE.

The afternoon and evening of the 19th were again spent in the microscopic examination of the very extensive material that had been collected.

Localities Visited.

14. At 5 A.M. on the 20th we sailed for Noakhali, and arriving at Ichakhali proceeded by road to Noakhali. On the way various plantations were visited and many specimens collected. The 21st and 22nd were then spent in Noakhali where Mr. S. K. Agasti, the Magistrate and Collector, afforded what assistance he could. The plantations around the sadar station were visited and cultivators from more distant parts of the district brought in and interviewed. On the midnight of the 22nd we again embarked, and reached Barisal on the 23rd, sailed for Khulna on the 24th, and reached Calcutta on the morning of the 25th May.

15. I was thus absent from Calcutta in all some 10 days, and I may explain that my tour of inspection occupied a much shorter period than I anticipated before starting, but I found there was no occasion to extend the enquiry at this season of the year. Sufficient material had, moreover, been collected to enable me to work out all that was likely to be ascertained, and it was found that having seen one or two plantations and talked with some 50 or 60 cultivators, was, for all practical purposes, the same thing as having visited every affected plantation.

CULTIVATION OF THE BETEL-NUT.

Mandar and Betel Groves.

16. ***Mandar Groves.***—In the districts of Backerganj and Noakhali (and very possibly in other districts as well) the Areca palms are planted in groves of *Mandar* (Erythrina indica). This Papilionaceous tree is supposed to improve sandy soils and to make clay soils more pervious. The cultivators are of opinion that the leaves enrich the soil, but they affirm that shade is required until the betel-nuts are full grown. It is probable, however, that it is protection from wind storms, more than shade from the sun, that is sought.

Branches of the *mandar* some 6 feet in length are planted in rows, the branches being placed 12 to 15 feet apart each way. The planting is done in February or April, not March. By about 2 to 3 years, on high lands, and 4 to 6 years, on low lands, the plantation is ready for the betel seedlings. In certain parts of Khulna district I was told they did not form *mandar* groves, but simply planted that tree on the circumference of their estates This system is also

followed in Kaukhali and Perozpur in Backerganj district. In the localities where that condition prevails I was somewhat surprised to find that the disease had not so far been recorded as doing serious damage.

CULTIVATION OF BETEL-NUT.

Seasons of Sowing.

17. *Seasons of Sowing.*—The betel-nuts are sown in October or November, the seeds being deposited 4 to 5 inches apart and the nurseries are either close to the homestead in shady places, or, if conveniently situated, the nurseries are made in the *mandar* groves themselves. The transplanting is usually done after 2 years, sometimes 3 or 4 years. For high lands the seedlings are transplanted in July, for low lands in February or April. In the first transplanting the betel-nuts are placed equi-distant from the *mandar* trees and thus 12 to 15 feet apart. But a second regular transplanting takes place when the first trees have come into bearing. Before this is done the *mandar* trees are cut down or only a fringe left around the circumference of the grove. The betel-nuts in a fully planted grove are thus about 6 to 7 feet apart each way. A certain amount of irregular planting takes place, however, as vacancies occur, and in selfishly conducted plantations the trees may be found here and there not more than 2 or 3 feet apart. It is also probable that there is a certain amount of self-sowing as it is not unusual to find two or three trees growing in a clump so close to each other that they could not be healthy. In most plantations also a distinct percentage of cocoanuts are interplanted among the betel-nuts, so that an old plantation in many cases has lost all its original regularity and become a dense jungle of palms with only a winding footpath leading to the owner's house. This generally stands on the bank of a small tank and near the middle of the holding The holdings range from 5 to 40 acres and in the larger plantations there may be three or four tanks.

Seas. Flow. and Fr.

18. *Seasons of Flowering and Fruiting.*—These may be said to be distributed throughout the year. The flowers that form in January will ripen fruit in October; the flowers formed in March will fruit in December and January. The harvesting period is from October to the beginning or middle of January, but occasionally the new flowers may begin to form in December or January on trees from which last year's fruits have not been collected. It is thus possible to collect fruits from a diseased tree, and such are known and recognised, though not liked. (*Conf. with paras. 37-8.*)

A. 1294-1328.

ARECA Catechu.

A Plague in the

CULTIVATION OF BETEL-NUT.

Duration or Possible Age.

19. ***Duration of Trees.***—If a few trees are planted near villages, but not in regular groves, the betel-nut may fruit when it is only 6 or 7 years of age. In plantations they rarely fruit much before the tenth or twelfth year. The trees subsequently put out in the plantation (just as the first set begin to flower) do not come into bearing for 20 years. There is no third planting except, as already stated, to fill up vacancies. Land formerly covered with betel-nuts, if replanted with them, even after a rest of several years in the form of *mandar* groves, does not, as a rule, yield until the palms are at least 20 years old.

20. It will thus be seen that it takes at least 30 years before a betel-nut plantation comes into full bearing. The fruiting life of a tree may be put at from 30 to 50 or 60 years after coming into bearing, and the total life of the tree might thus be stated at from 60 to 100 years. Several of the cultivators examined by me admitted that their plantations had been laid out by their grandfathers, if not at a still more remote time, and had continued to yield for at least the past 60 to 70 years without the slightest attention on their part, further than to occasionally top dress the soil or hoe down the weeds. But even that amount of labour is not bestowed on these profitable plantations every year, and indeed many cultivators never give any labour to their betel-nut groves.

OPINIONS OF THE CULTIVATORS

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It may serve a useful purpose to record here very briefly a few of the opinions and replies elicited from the cultivators:—

Densely Planted.

21. In the Mendiganj Thana the disease first appeared in November and December of 1892, in a plantation in the village of Lashkarpur. The owner of the plantation (Ahmuddin Shikdar) said that he lost about $\frac{1}{18}$ of his trees on that occasion. The disease seemed to stop for some time, but re-appeared in the following September. Before the plucking season in October 1893 he had lost about half his trees. The disease has continued ever since and he has now lost all his trees, young and old alike. He owns about 16 bighas of land, an area that, he says, formerly contained between 5,000 and 6,000 betel-nut trees.

22. None of the other gardens in the neighbourhood were seriously injured before January 1896. The first to be affected was that belonging to Shumsuddin Aken, which lies to the south. The prevailing wind in January is from the north. But very shortly after (or in fact about the same time) the plantation belonging to Nabu Shikdar and also those belonging to Nado Jemadar and to Mohammad Take, were affected, and these lie to the north.

23 The village of Ramnathpur, which lies to the east of Laskharpur and about ½ mile distant, became attacked in January 1896.

OPINIONS OF THE CULTIVATORS

The village of Lashkarpur may be said to have lost at least 90 per cent. of its betel-nuts, and the population have been reduced from a state of opulence to one bordering on poverty. On one occasion we came across one of the neatly built and even ornamental houses of the betel-nut cultivators deserted and empty. We asked our guide the reason, and he pointed to the forest of dead stumps of betel-nuts The owner preferred, he said, to seek employment elsewhere rather than to face the future and have to pay rent on a useless property.

First Indications.

24. ***Indications of Disease.***—Some twenty cultivators were present when the above information was obtained. They stated that the first indications of the disease were the withering of a few leaflets (pinnæ) of one of the innermost leaves. In about 8 to 10 days the whole leaf is seen to have withered. The next leaf to be affected is that immediately outside. In about 20 to 30 days the bud and innermost leaves, which still remain green, fall off through the decomposition that is set up at the point of their union to the top of the stem. If a tree be felled just before the crown of leaves falls off, it will be found to emit an offensive smell—and the bud when it falls to the ground of its own accord gives out the same smell.

Supposed *causes.*

25. ***Their Explanation of the Origin of the Disease.***—The cultivators regard the disease as due to wind and damp atmosphere, connected with the cyclones that often occur about October. This followed by dry weather in February and March completes the destruction. But they were unable to account for the admitted fact that during the last outbreak it was worst during January, or just before the occurrence of the dry spring. In April they had rain and hail, after which they observed the disease began to abate, and affected trees to give indications of recovery. In Backerganj there is usually rain in January, but last year there was none, so that a want of rain up to April might be regarded as associated with the severity of the outbreak of 1895-96. The cultivators affirmed that in February and March the soil became abnormally dry, but they immediately added that they had found the disease to prevail with equal severity on plantations with damp low-lying soil and those on soil that had become completely dryed up by January and February. They would not admit having observed any special prevalence of the disease on soils of one kind more than another.

26. ***Age of Affected Trees.***—Speaking of the age of the trees affected, the cultivators first affirmed that old and young trees (even seedlings) were alike attacked. When asked the reason why the plantations through which we had marched from Patharhat to the Mendiganj Thana were

A. 1294-1328.

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CULTIVATION OF BETEL-NUT.

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OPINIONS OF THE CULTIVATORS

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Densely Planted.

21. In the Mendiganj Thana the disease first appeared in November and December of 1892, in a plantation in the village of Lashkarpur. The owner of the plantation (Alimuddin Shikdar) said that he lost about $\frac{1}{16}$ of his trees on that occasion. The disease seemed to stop for some time but re-appeared in the following September. Before the plucking season in October 1893 he had lost about half his trees. The disease has continued ever since and he has now lost all his trees, young and old alike. He owns about 16 bighas of land, an area that, he says, formerly contained between 5,000 and 6,000 betel-nut trees.

22. None of the other gardens in the neighbourhood were seriously injured before January 1896. The first to be affected was that belonging to Shumsuddin Aken, which lies to the south. The prevailing wind in January is from the north. But very shortly after (or in fact about the same time) the plantation belonging to Nabu Shikdar and also those belonging to Nado Jemadar and to Mohammad Take, were affected, and these lie to the north.

OPINIONS OF THE CULTIVATORS

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Supposed causes.

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A.

OPINIONS OF THE CULTIVATORS

not diseased, the cultivators replied that these were young plantations. But it may be added that they were on the banks of a river whereas those of Lashkarpur are at a considerable distance from any stream. The degree of subsoil moisture may, therefore, be assumed to be very different in the two localities Moreover, the cultivators invariably pointed to the lowness of the water in their tanks as an indication of the untowardness of the year.

The consensus of opinion seemed, however, to be that when the disease first appeared it attacked the old trees, but that rapidly it showed no special favour for old more than young trees. Some of the cultivators even affirmed that it had appeared on the cocoa-nut palms, but the one specimen of this shown to me might have been struck by lightning, or have lost its crown of leaves from any one of many other causes. I saw nothing to justify me in thinking the peculiar disease of the betel-nuts had extended to the cocoa-nuts also, though it is significant that many cultivators affirmed that this was the case.

27. At Noakhali a large number of cultivators had assembled and the information obtained from them confirmed the above, and amplified here and there the details. The evidence of one or two may, therefore, be here given.

Sparsely Planted.

Upsaruddin, of Char Matua, had a five-acre garden containing 700 to 800 trees. The trees began to die in December 1893, a lull came about February or March; the disease re-appeared in December 1894, and went on till March 1895; returned in December 1895 and continued till March. He has only 100 trees alive now.

28. Mohammad Amjad, of Rameshwar, said, they had a cyclone in October 1893 He noticed the betel-nuts dying in November following. The leaves all turned yellow simultaneously and by February he had lost ¾ of his plants. There was again a lull till the cyclone of October 1895, when the disease re-appeared.

Another cultivator gave practically the same opinions. He had 2 acres bearing 1,500 trees, he has only about 100 left, and these are young trees, not bearing.

29. Ali Meah, of Sharla, said he had 4 acres under betel-nut. He attributed their having died to the order issued by the Collector to have them counted—he sagely remarked that "you do not count your children." He did not think the cyclone of 1893 had anything to do with the disease, for the reason that they had often before had cyclones and these were not followed by a plague. He was quite sure that Government was responsible for the plague, and remarked, "Counting with the object of increasing rent or oppressing the ryot is offensive to Allah."

OPINIONS OF THE CULTIVATORS

Sequence of Attack.

He added that, while young and old trees were alike affected, there was a greater percentage of death among the old. He said that it first appeared as spots on certain leaflets of the second or third leaf from the inside, but that he had also seen the bud first showing the symptoms of disease. If the innermost leaves are first attacked, the course of the disease is more rapid. From the time of first appearance it generally takes 10 to 12 days in dry weather and nearly a month in wet, before the tree is killed. The disease has for the present disappeared, in fact certain trees that were distinctly attacked, he said, had begun recently to recover. But he regards it as certain that this recovery is only temporary, that there is no real recovery, on the contrary, that those very trees will die later on in the year He repeated when cross-questioned that the disease most commonly commenced on the second or third leaf, but that he had seen the bud first attacked, and had also observed the course reversed, the disease extending from the outermost leaf of all to the bud.

Recovers with Rain.

PRELIMINARY OBSERVATIONS.

30. Having thus mentioned the localities visited and the opinions of the cultivators, I shall now proceed to detail some of the observations made by me, but I do not think it will be necessary, except on rare occasions, to specify the localities where these were recorded.

31. My first impression was that we had to deal with several, not one disease. I asked the cultivators to point me out diseased trees and I ordered these to be cut down one by one. While that was being accomplished I questioned the cultivators as to the symptoms by which they recognised "the byaram" "(the disease)" and the only sort of opinion they could give was that the leaves had begun to wither.

Symtoms of Disease.

32. *External Symptoms.*—In one case a few pinnæ, on the second or perhaps the third leaf from the central bud, had withered; in another the whole of that leaf had turned to a uniform reddish yellow colour, but stood erect; in a third two or three leaves were more or less withered, some having lost all shade of red, and dried up into a dirty straw colour and become pendent. But in all three examples the bud and first leaf stood erect, were green and quite healthy looking. In a fourth the terminal bud had toppled over and was suspended among the withered leaves. In still another the entire terminal crown of leaves had fallen off leaving a dead stump —a monument of the completed course of destruction.

BETEL-NUT PALM DISEASE

Influence of Cyclones.

stated there were found many dead trees with pendent crowns of leaves that might easily have been killed by the cyclone of October. In such cases the crown of leaves had not separated from the stem; the bud and leaf-stalks had not become rotten, but were dried up and reduced to a fibrous condition from being tossed about in the wind, owing to their having remained dangling to the stem for some four or five months. This is clearly a different condition from that in which the tree becomes leafless in little more than one month from the date of giving external indications of being first attacked, and where the tissues become rotten and putrid. Moreover, the continuance of the attack, trees being seen one after the other to be affected during a period of at least four or five months from the date of the cyclone, could obviously not be a direct consequence of injuries sustained at one and the same time. During the past 20 years there must have passed over the Backerganj and Noakhali districts many cyclones, but only on two occasions have these been followed by a plague *among* the *betel-nuts.*

Climatic conditions.

41. It was thus clear to my mind that by a coincidence possibly, a cyclone had preceded the out-break of the disease—a disease that probably requires for its epidemic growth the climatic conditions that follow the cyclonic period. The injury done by cyclones, where not associated with such a disease, would be regarded as ordinary casualties. The betel-nut is undoubtedly a delicate palm and would be readily injured by severe storms, so that a certain percentage of deaths very likely always follows the cyclonic period, though the cultivators take no special notice of that fact. It is only when an epidemic occurs that they become alarmed and look about for an explanation, and then the peculiarity of the disease appearing after the close of the cyclonic period may naturally suggest the cyclone as its cause.

42. The fact that the disease had spread from the districts where it first appeared, into remote regions where there had been no cyclones, would seem to dispose of the cyclonic theory. It may be mentioned that on my return to Calcutta I had diseased betel-nuts sent me from several districts, besides those of Eastern Bengal, and myself discovered a few isolated trees badly affected in gardens in Calcutta. It would be difficult to account for the communication of a contagious disease to single trees in the heart of a great city and several hundred miles away from the chief region of betel-nut cultivation—and yet I have little doubt they were killed by the same disease as that which

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raged in Eastern Bengal during the period of my tour of inspection. What is still more significant, while the disease had practically stopped in Backerganj and Noakhali, it would seem to have subsequently commenced at Sibpur near Calcutta. But if climatic conditions be assumed as possibly originating the disease, there would very probably be little difficulty in accounting for isolated and simultaneous manifestations. BETEL-NUT PALM DISEASE.

PARASITIC FUNGI AND ALGÆ.

43. During my rapid tour of inspection to Eastern Bengal, I had ample opportunity to hunt for external parasitic organisms, and with three or four microscopes at hand could ascertain, with some degree of certainty, whether those seen could be accepted as causing, or even being in association with, the disease. I requested Mr. Mukharji, therefore, to re-discover and show to me the parasitic fungus to which he attributed the death of the palms. In this he failed absolutely, but accounted for his failure by the changes that had taken place during the past two months. There was of course a certain amount of probability in that explanation. It was, therefore, with the very greatest care that I examined the epidermis of the stems, leaves, leaf-sheaths, and buds, for any such manifestation, for I felt satisfied that even with the most advanced stage of such a fungus there need be no difficulty in recognising the mycelia and withered fructifications, or possibly in detecting the resting condition of the fungus. The withered and dead leaves very frequently (and dependent on the extent of their decay,) manifested certain saprophytic fungi, but neither upon these, nor on the living and dying structures, could any trace be found of a parasitic fungus that would in any way account for the destruction of the palms. Parasites.

44. Indeed only one parasite was discovered, namely, the lichenoid condition of the Alga known as **Cephaleuros mycoidea.** This was seen to form on the old stems immense elevated patches (sometimes as much as an inch in length) brownish red with sometimes a dead portion in the centre and a darker outer rim. These occurred up and down the stems, and side by side with numerous patches of grey lichen. But it was also noted that the outer large green leaf-sheaths were copiously besprinkled with smaller more red-looking patches of that Alga than those seen on the stem. The small patches on the leaf-sheaths were carefully studied and

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BETEL-NUT PALM DISEASE.

Parasitic Alga.

sections made through them to ascertain the depth of their parasitic attachments. They were readily seen to be very nearly epidermal in their action, though the cells underneath the patches to a certain depth were often much discoloured and in some cases even killed.

I had previously had occasion to study this Alga on the tea plant, and was well aware that sometimes it became deep-seated, and is then a dangerous parasite. On the leaves of the tea bush, small round orange-red patches of this parasite, that look to the naked eye very much like little patches of a foliaceous lichen, may be found in nearly every garden in Assam, but only in *one or two* localities does it assume its second phase. In these localities, however, it becomes deep seated on the young twigs of the tea plant. It ceases to be a lichen-like epidermal harmless parasite and assumes its more direct parasitic condition. It does not in that case form circumscribed superficial patches, but penetrates the epidermis and emerges on the surface of the twigs in the form of an extensive pile of very minute orange-coloured fructifications. The limitation of its destruction in that case is indicated by a pronounced *orange-*yellow line of demarcation, separating the portion of the dead from the living twig. As it advances, the tissues through which it has passed turn livid, and soon wither up and die.

45. *Demarcating Line.*—I have gone into these details here because in every case where the leaves of the betel-nut were seen to be killed by "the *byaram*" I observed an orange-coloured line of demarcation between the living and the dead tissues. It was only natural to infer that the agent of destruction might be recognised at that point. But I was surprised to find that many trees that gave no indication of the presence of Cephaleuros mycoidea possessed the line of demarcation in quite as pronounced a form as in those with that Alga in great profusion. Further, though I made many sections through leaf-sheaths that showed the Cephaleuros and those where it was not present, I could not detect any indications of there ever having been penetrating mycelia or other foreign organisms within the tissue of the palm. I was thus forced to the conclusion, though reluctantly, that Cephaleuros at least could have nothing to do with the destruction of the betel-nut palms. I say reluctantly, for I had failed absolutely to detect any other epidermal parasite on these palms and Cephaleuros was frequently present to a very considerable extent.

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BETEL-NUT PALM DISEASE.

Parasitic Alga.

46. Before leaving the subject of Cephaleuros, however, I would desire to add a further circumstance of no small value. I never came across a leaflet of the palm that bore the alga so that that parasite must be held innocent of the withering of the leaves in the manner described. When decay had invaded the whole leaf, and was descending into the sheath, then the line of demarcation to which I have alluded was seen to be formed. The portion of the sheath usually below that line, being still living and green, was that, and that alone, on which Cephaleuros was to be found.

Absence of Penetrating Mycelia.

47. But, while I had failed to discover any deep-seated action for Cephaleuros, I had also failed to recognise within the tissue of the palm indications of the mycelia of a fungal parasite. I must have cut and examined hundreds of microscopic sections, lengthwise and transverse, through leaf-sheaths, leaves, stems, roots and buds. In no instance did I come across the slightest indication of the presence of penetrating mycelia. This circumstance, when taken in conjunction with the entire absence from the epidermis of any fungal organisms, left no room for doubt that if the death of the palms was caused by a fungus at all it very possibly would be found to be of a very unusual type, the life-history of which in all probability would prove a new and novel story to the already long and diversified literature of plant diseases.

DECOMPOSITION OF TISSUES.

Stages in Decomposition.

48. *Stages in Decomposition.*—Before proceeding to deal with the microscopic peculiarities of the diseased palms, I think it as well to detail certain other peculiarities I was surprised to find the greatest irregularity in the condition of the uppermost three feet or so of the trees felled. In one with only a few leaves withered, and which I was told had only recently been attacked, I found the leaf-sheaths of the three or four leaves immediately around the terminal bud, and the bud itself, completely decomposed into a watery fluid contained within the reed-like tube formed by the remaining leaf-sheaths. As I have explained, the extremity of the betel-nut stem consists of the embracing leaf-sheaths, which, for a considerable portion of their length, constitute complete tubes one inside the other. The young stem is contained within this series of tubes for some distance, the remaining portion of the tube on the top being filled up by the

BETEL-NUT PALM DISEASE.

youngest leaf of all. It is this unexpanded young leaf, standing erect in the middle of the crown, that I have for convenience designated the central bud, though it should now be understood that the bud itself is right at the base of the first leaf and completely within the tube.

Various Stages in Decomposition.

In the stem hewn down, to which I have just alluded, the central leaf stood erect though its lower half right down to the bud was completely decomposed. I collected a quantity of this liquid ; it was quite clear and had next to no smell. In a short time after exposure to the air it became turbid and acquired an offensive smell.

49. In another tree, where the leaves were nearly all withered, I found no fluid, no empty tube, but the whole of the inner leaf-sheaths and bud were reduced to a pulpy white mass that gave out a most offensive and sickening smell. I looked for the maggots recorded above (*Para. 5*), but found none.

50. In a third palm, which seemed externally quite as far gone as either of the above, there was no decomposition, no smell, and the leaf-sheaths and young stem when slit open showed no discolouration. They looked in fact quite healthy.

51. In a fourth, very little affected so far as external indications were concerned, the transverse sections of the leaf-sheaths and stem showed discoloured yellow and brown spots that corresponded to the position of the fibro-vascular bundles. But there was no fluid, no rotten putrid tissue.

52. The examples three and four above, I was told, were trees that had for the present had recovered from the disease, but would have most undoubtedly died next December.

53. In still a fifth, the bud had fallen off and a leafless stump was all that remained.

The effect of decapitation is usually visible a little below the point of actual location of the bud, say two or three feet below the extremity of the tree. The first indication of this is a constriction of the stem just outside the leaves. This extends until the crown becomes top-heavy. The central erect portion first falls over and then the whole crown of leaves tumbles to the ground. The constriction of the stem continues until the stump becomes somewhat pointed and appears as if the plant had been killed by a string tied tightly around the green portion. It may then be noticed that a line of depression forms lengthwise on one side of the stump, the external ring of hard wood falling in, as it were, through the interior tissue decomposing from

BETEL-NUT PALM DISEASE.

the bud downwards. It will thus be noted that here again I failed to discover any uniform process of destruction such as might be seized upon as indicative of a localised and parasitic disease.

Not of Parasitic Origin.

54. I had, in fact, failed to see any fixed course in the withering of the leaves; failed to find a parasitic fungus either on the epidermis or within the tissue of the plant; and I had also failed to detect any very precise course of decomposition of the tissue. There could be but two admissible explanations of these significant failures, in the face of such wholesale destruction—namely, that either the disease had run its course, and for the present at all events, had practically disappeared, or that it was a malady that might be characterised as of a constitutional character not the result of a specific parasite. The cultivators were unanimous that it appeared in December, and after March ceased to attack any more trees. It was thus certain that to study the disease with any hope of being able to discover its causation it must be taken in hand in December or January and that my visit in that case was made too late in the year.

Season of Appearance.

55. But one point I feel confident in re-affirming, namely, that whatever the disease may be it can hardly be a fungus that produces penetrating mycelia and that carries its fructifications to the surface, since I was almost certain to have seen the results of such penetration or the remains of the withered fructifications.

MICROSCOPIC STRUCTURES.

56. *It is necessary to examine a few of the structures of healthy* plants, before proceeding to deal with pathological manifestations. As in all other palms, so in the betel-nut, transverse sections of the stem, root, or leaf, examined under a low-power microscope, will be seen to consist mainly of large thin-walled cells so loosely packed together that they leave, more or less frequently, intercellular spaces, that is to say, openings between the cells. Tissue of this nature has been designated the FUNDAMENTAL TISSUE.

FUNDAMENTAL TISSUE.

In the root and stem the cells of the fundamental tissue are broad-oblong or rotund, and show accordingly small triangular intercellular spaces, but in the fully formed structure of the leaf-sheath the cells are sometimes linear-oblong. They are then arranged in a definite manner, and frequently manifest very large intercellular spaces from the linear cells being divergent. But the greatest possible variation may be witnessed according to the age or position of

AREGA Catechu.	Microscopic Examination

FUNDAMENTAL TISSUE.

the tissues examined. Thus, for example, if a series of transverse sections of the young stem be made at every inch from the actual growing apex, and for a foot or so downwards, the most marvellous transitions in form may be witnessed. So in a like manner a set of transverse sections of the outermost leaf-sheath will differ materially from those of the less mature internal leaf-sheaths. Moreover, within the same leaf-sheath considerable diversity may be witnessed in the relative developments of the various parts, according to the position from which the sections have been taken. In the one the cells of the fundamental tissue may be seen to be nearly as broad as long, in another three or four times as long as broad, meeting each other in fact at their extremities only. In still a third transverse section the cells of the fundamental tissue of the leaf-sheath may be seen to be linear-oblong, and so placed as to touch each other throughout their length, being more or less parallel to the epidermis.

The Cell-Wall. Cell Contents. Nucleus. Chlorophyll Grains. Starch Grains. PARENCHYMA PROSENCHYMA.

57. It may also be recorded, regarding the fundamental tissue, that its cells have remarkably thin *cell-walls*; that the protoplasmic *contents* are quite transparent; that an exceptionally large *nucleus* may be discovered within each cell; that in superficial structures *chlorophyll grains* are discernible; and that small round *starch grains* are present in most of such cells. This condition of the cell has been designated PARENCHYMATOUS, in contra-distinction to PROSENCHYMATOUS, in which the cells are elongated.

Starch Grains. *Conf. with paras. 60a, 74.*

58. Returning to the subject of the starch grains, it will be observed that they are very abundant in the root and mature stem, become less abundant on ascending toward the growing apex of the stem, and less abundant in the mature leaf-structures than in the young leaves. The cells of the fundamental tissue of the root and lower stem will also be recognised as containing numerous bundles of needle-shaped *raphides*.

Raphides.

These details regarding the parenchymatous tissue of the betel-nut (which might be said to apply to any palm) have been gone into here, because in the diseased condition they undergo certain very remarkable modifications.

FIBRO-VASCULAR BUNDLES.

59. *Fibro-Vascular Bundles.*—Scattered throughout the fundamental tissue will be seen compactly built structures that manifest no intercellular spaces, and the cells of which are, for the most part, in the prosenchymatous condition. Neither nuclei nor starch

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FIBRO-VASCULAR BUNDLES.

grains are usually seen within these cells, and, moreover, many of them have been fused as it were into long tubes, or *vessels*, by the absorption of the extremities of the cell-walls. These are the FIBRO-VASCULAR BUNDLES. The micro-photograph,* *Plate I., fig. 1*, shows the transverse section of a fibro-vascular bundle in the leaf-sheath.

60. For convenience each bundle may be spoken of as consisting of three well-marked portions :—

Bundle-sheath.

(*a*) A protecting *sheath* composed of two layers of widely different cells. The cells of the outermost layer differ from those of the fundamental tissue mainly in being smaller and more closely compacted, and in being often more highly charged with starch grains. The inner layer of the sheath consists of thick-walled cells—SCLERENCHYMA. In *fig. 1* the outer layer consists of the two or three rows of small cells on the circumference: the inner layer is best seen in the dark apicular bed. In *Plate III., fig. 7*, it is beautifully shown in the healthy bundle to the right where it forms a dark horse-shoe-shaped patch.

SCLERENCHYMA.

Pitted Vessels.

(*b*) A series of *vessels* or tubes enclosed by thick-walled cells that are in a transitionary stage of development into vessels of the character they surround. There are usually one, two, or three large PITTED VESSELS embraced by thick-walled pitted cells—the TRACHEIDES. Below the pitted vessels are placed a series of SPIRAL VESSELS, some with the spiral deposit uniformly formed, others more open and irregular, but never ANNULAR. There may be one or two such vessels, or as many as 30 or 40 compacted together by *tracheides* in various stages of development. The series of pitted and spiral vessels with their surrounding tracheides are collectively designated—the XYLEM. In *Plate I., fig. 1*, the two large eyes near the middle are the pitted vessels and the six or seven smaller ones below are the spiral vessels.

Tracheides.

XYLEM.

It may be of interest to add here that it is supposed to be within this portion of the fibro-vascular bundle, mainly, that the sap rises from the root to the growing bud,

* I would here explain that I am indebted to my friend Mr W. Simmons (Secretary of the Microscopic Society of Calcutta) for having very kindly prepared the Micro-photographs given in this paper. —*G. W.*

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though it should be recollected that no fluid passes within the vessels themselves. (*Conf. with para. 72.*)

Circulation of Sap.

It ascends within the cellular portions of the xylem chiefly in consequence of the following forces:—

The Crude Sap or Ascending Current.

by the suction caused through *Transpiration* from the leaves;

by the constant adjustment of the specific gravities of the fluid contents of adjacent cells—*Osmosis;*

by the chemical affinity of cellulose for water—*Imbibition*—a power that is cosequently strongest in the cells with thick walls; and

by the law of *Capillary Attraction.*

But the vessels of the fully formed wood, more especially the pitted vessels, contain air, and only abnormally fluids or other substances.

(*c*) Between (*a*) and (*b*) on the upper half of each bundle one or two patches of thin-walled cells will be seen. Interspaced with these cells may also be recognised numerous sieve tubes. This portion of the bundle has been designated the PHLOEM, and it is the region within which the descending current of sap passes—the elaborated sap—the prepared food of the plant. The Phloem is seen in *Plate I., fig. 1, i.e.*, the two circular clear spots built up of small cells below the dark apicular sclerenchyma and above the pitted vessels.

PHLOEM.

The Elaborated Descending Current

RELATIVE POSITIONS.

61. ***Staining Sections.***—The proportions of these constituents of the fibro-vascular bundles may be seen to vary greatly, but their relative positions are not susceptible of change. In transverse sections the phloem is placed above the xylem, that is to say, in the stem and root it is directed toward the periphery and in the leaf toward the lower (outer) epidermis. To assist the observer to recognise these structures, more especially when in longitudinal section, it is desirable to call in the aid of one or two staining solutions, that is to say, substances that will uniformly impart colour to certain portions of the tissues examined. It will suffice to employ for this purpose three tinctorial reagents. *Picrocarmine* will give a pink tinge to the protoplasm and nucleus of parenchymatous tissues, while *aniline-violet* will impart a bright blue to the vessels and cell-walls. *Iodine* will stain the starch grains blue and impart a rich yellow tint to lignified tissues, and colour in this way certain

Staining Sections.

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cellulose deposits not stained by the violet. With the aid of these and other similar well-known tinctorial reagents it becomes possible to distinguish the relative parts of the bundle, however disproportionately they may be developed.

The Leaf sheath.

62. *The Leaf-sheath.*—Perhaps the best way to examine the betel-nut is to commence with transverse sections through the leaf-sheath, choosing for this purpose the second or the third sheath (counting from the outside) and making a transverse section through about the middle length of the sheath. The fundamental tissue of the central portion of the section will be seen to consist of elongated cells arranged in a beautiful manner parallel to each other and gradually tapered in length. Two or three rows of these cells encircle each bundle, and thus produce a sort of diaper pattern with the fibro-vascular bundle as the central feature of each diamond-shaped space. As if to denote the limitations of these spaces some 12 to 16 miniature fibro-vascular bundles are arranged on the circumference, in which every third one is larger and more fully formed than the intervening pair. The micro-photograph, *Plate I., fig. 2*, shows this arrangement of fundamental tissue and fibro-vascular bundles.

Outer Margin.

63. Towards the lower margin (that is, the outer surface of the leaf-sheath) the fundamental tissue will be observed to become less methodically arranged and the cells more rounded. The bundles in this position are also smaller and more numerous though at first they are as it were more elongated (*transverse section*), the development being on the apex and consisting mainly in the greater production of the sclerenchymatous portion of the bundle-sheath. Ultimately the bundles, crowded towards the margin, are seen in transverse section to consist of small circular patches of sclerenchyma with or without a clear parenchymatous centre, but completely devoid of any trace of vessels. *Plate I., fig. 3*, shows this condition in a transverse section of the young leaf stalk. It should perhaps be here explained that in its course through the stem each bundle is thickest a little above its middle length, and that as it abruptly *arches* upwards and outwards toward the periphery, in order to pass into the leaf, or is extended downwards and outwards in the direction of the root, it is gradually tapered off in thickness. It follows that many of the small and imperfect bundles in the periphery of the stem or within the leaf, are bundles which, if traced upwards or downwards,

EXAMINATION.

would be found to be fully formed. To speak of them, therefore, as imperfectly formed is (in many cases) but relatively correct, namely, to the other bundles within the field of the microscope.

64. The *epidermis* consists of one row of closely packed minute oblong cells (with thin walls), and which show no intercellular spaces except the somewhat peculiar and abundant stomata which open into the alternate positions between the sclerenchymatous patches. Below the epidermis is placed a cuticular layer of three or four rows of small rounded cells also with remarkably thin walls, the cells being less than half the size of those of the adjacent fundamental tissue. It may be remarked that this condition should be eminently adapted to free transpiration, but ill-suited accordingly to any abnormal drought.

Inner Margin.

Conf. with para. 84.

65. Turning observation toward the upper (inner) surface of our leaf-sheath section, only a slight diminution in the size of the fibro-vascular bundles, with little or no crowding of imperfect bundles, will be seen toward the cuticular region. The cells of the fundamental tissue are, however, greatly elongated and so arranged as to repeatedly leave large intercellular spaces. The epidermis is similar to that described on the opposite margin, but the sub-cuticular layer is many times as thick as that of the under-surface. It consists of some 30 or 60 rows of greatly elongated parallel cells closely compacted together, and, in consequence, the fibro-vascular bundles are seen for the most part to be some distance from the epidermis.

FORMATION OF FIBRO-VASCULAR BUNDLES.

66. ***Formation of Bundles.***—Although it may be regarded as a slight departure from the description of the healthy tissues, that ultimately become changed pathologically, it may be here stated that the formation of new fibro-vascular bundles may be traced in either of two, if not three, methods:—(*a*) The great apicular horse-shoe-shaped bed of sclerenchyma, present in every fully formed bundle and which constitutes the inner layer of the bundle-sheath (*Para. 60 a, Plate I., fig. 1*) may be seen (on transverse section) to elongate as it were toward the periphery. Ultimately a semi-transparent spot appears within this expansion which may be observed to gradually assume the condition of the phloem. In course of time these new centres are severed from the old bundles, and in longitudinal sections (through the thickness of the leaf-sheaths) such new bundles appear as branches, which may be even traced obliquely through the tissue until they enter into fusion with other bundles,

FORMATION OF FIBRO-VASCULAR BUNDLES.

Anastomosis of Vessels.

thus producing an anastomosis of the fibro-vascular system. But this condition, so far as the leaf-sheath is concerned, will be observed to be most frequent within or adjacent to the sub-cuticular region where, as already stated, numerous imperfect bundles are crowded together. Similarly, the branching and anastomosing of bundles within the stem occurs in the bark-like zone of crowded bundles—a region in which extensive beds of sclerenchyma may be witnessed, due to the fusion of bundles (*Plate I., fig. 3*). But at the nodes (or joints) an even more complete system of branching may be traced, where a perfect plexus, as it were, occurs, that gives to the leaves secondary branches from the fibro-vascular system of the stem.

(*b*) But to return to the subject of the formation of new bundles. In the second place, bundles may be seen to be formed from minute patches of the peculiar prosenchyma here dealt with, which originate within the fundamental tissue and gradually develop into bundles. These may have been cut off at an early stage of their existence from the bundles before the formation of a phloem, or they may have been spontaneously formed in the fundamental tissue. As seen near the outer margin of the leaf-sheath or on the periphery of sections of the stem, the majority would appear to be formed from the apex (transverse section) of the older bundles immediately behind. They very frequently remain for a period without showing any phloem, and may even expand and coalesce into great irregular beads of sclerenchyma immediately underneath the cuticle, without manifesting any tendency to form definite bundles.

(*c*) It would also appear probable that bundles originate by a third process, namely, the formation of a band of cells that assume the conditions of the phloem, and ultimately become surrounded by a prosenchymatous sheath.

67. ***Occurrence of Vessels.***—In point of time and place the spiral vessels are first to appear within the bands of sclerenchyma destined to be converted into fibro-vascular bundles. The pitted vessels are formed at a much later period, their presence denoting fully formed bundles. A few of the interior sclerenchymatous cells of the young bundle assume the condition of tracheides, and others gradually form spiral vessels. But prior to the appearance of vessels a central phloem has invariably been formed. It is thus evident that the essential conditions in the formation of a fibro-vascular

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FORMATION OF FIBRO-VASCULAR BUNDLES.

bundle are a well-developed sheath of sclerenchyma surrounding a parenchymatous central cord. The precedence of these conditions is so invariable in all the younger tissues, that the fibro-vascular system in its ultimate extensions and anastomoses may be said to be represented by cords of sclerenchyma, with or without a parenchymatous central band.

68. *Bundle-sheath.*—The sclerenchyma of the inner layer of the bundle-sheath may readily enough be recognised. Its cells are made to assume a greenish tint by picrocarmine and are then seen to form a peculiar horse-shoe-shaped apicular cap on the top margin of the transverse section of the bundle (*Plate I., fig. 1*), the dark portion at top of bundle. From the centre of this embracing concavity a dividing band of cells penetrates through the pink-coloured parenchyma of the phloem, and on nearing the xylem gradually spreads out and becomes less and less prosenchymatous, until ultimately it merges again into the condition of the tracheides around the vessels. Under the influence of iodine the apicular cap of sclerenchyma turns orange yellow, the remaining portions canary yellow, while the phloem is not stained

Right at the further extremity of the bundle there is a similar sclerenchymatous horse-shoe-shaped embracing bed, though very much less distinct than the apicular one, and with the majority of its cells stained by iodine yellow instead of orange In *Plate I., fig. 1*, this is not very distinct, but is indicated by the dark cells near the limitation of the bundle. These two beds of sclerenchyma may almost be said to be connected by two chains of prosenchymatous cells that complete the inner sheath. Within this sheath there may be seen a fairly large patch of thin-walled cells, of a more or less parenchymatous nature, that extends from the lower cap of sclerenchyma to the tracheides of the spiral vessels.

69. Outside the sclerenchyma may be recognised the outer layer of the bundle-sheath This is purely parenchymatous, it belongs to the fundamental system, but is clearly adapted as a special limiting layer to the bundle The cells are much smaller than those of the fundamental tissue, and, as seen in longitudinal section, are greatly elongated On the apex of the bundle this outer layer of the bundle-sheath is most highly developed, and in the case of the bundles met with in the stem where it may be seen to have developed into many times the size of all the other portions of the bundle viewed

FORMATION OF FIBRO-VASCULAR BUNDLES.

collectively. This condition is very well shown in the micro-photograph (*Plate II., fig. 6*), where the spiral vessels and cells of the xylem are dark coloured through the presence of a deposit within them.

70. ***Structure of the Stem.***—In fact the apicular parenchymatous sheaths have expanded into immense patches each with its dwarfed xylem and phloem thrown into the lower extremity. The fundamental tissue of the stem has thereby been compressed into narrow dividing ridges between these great oblique expanses of small-celled parenchyma (*Fig. 6*).

71. Moreover, transverse sections of the stem might, near the apex, show many bundles almost lengthwise, owing to so many in that position having turned acutely outwards to enter the leaves. In this condition the parenchyma of the outer bundle-sheath is not only revealed as made up of elongated cells, but the nuclei of adjacent cells occur uniformly in the same positions, and thus give these ribbon-like bands of elongated cells a jointed appearance when viewed by a low power. When it is recollected also that new bundles can be seen to be thrown off from the sclerenchyma, and that at the joints (or nodes rather) of the stem numerous branches may be traced, it becomes apparent that the immense development of woody tissue (the sclerenchymatous inner layer of the bundle-sheath (*Plate I., fig 3*) and the equally great production of the parenchymatous outer layer of the sheath (*Plate II., fig. 6*) must be intimately connected with the life of the plant.

72. ***Circulation of the Sap***—I am thus disposed to regard the view advanced by many botanists (*paragraph 60*), that the ascending crude sap passes within the xylem and the descending elaborated fluid within the phloem, as very possibly too circumscribed Those divisions of the bundle are doubtless primarily concerned in the circulation, since in many parts of the plant (as in the leaf-sheath and leaves) the vascular system consists mainly of a series of what might be designated theoretical fibro-vascular bundles. But a very much larger proportion of the palm tissue consists of the sclerenchyma of the sheath than of the xylem of the bundles. It is accordingly difficult to believe that the theory of imbibition should not be admissible as operating powerfully within bands of tissue of this nature, the more so since these manifest within the external structures an almost complete anastomosis, and are exceptionally highly developed in the root. In the same way I am disposed to regard the distribution of the elaborated sap within the stem as passing to some extent at

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FORMATION OF FIBRO-VASCULAR BUNDLES.

least through the so-called parenchymatous outer layer of the bundle-sheath, seeing that the phloem of the bundles of the stem is relatively very minute. In the root it is otherwise; the descending current of elaborated sap apparently passes exclusively within the phloem of the more central fully developed bundles. And, in part support of this view of the parenchyma of the bundle-sheath, I would mention the further fact that the formation of starch grains and raphides is mainly (one might almost say entirely) within the fundamental tissue of the stem and root, whereas in the leaf, starch grains may be witnessed as most abundant in the parenchyma of the outer zone of the bundles.

73. ***Formation of Lateral Flowering Buds.***— Before passing to the consideration of the morbid structures it may be as well to mention, in conclusion, that in longitudinal sections through the terminal bud of the betel-nut palm, the formation of the flower buds may be traced. From the base of each leaf, on its inner face, and distinctly above the level of the apex of the stem, a small portion of the cellular tissue of the leaf may be seen to be severed. This becomes the protecting sheath of the flower bud. In the interior of the sheath a miniature bud, very much like the terminal leaf-bud, is gradually formed, which has minute leaves embracing its apex, but at this stage the vascular plexus may be observed to have furnished no offshoot for the young flower-bud. It is composed at present of cellular tissue only, and indeed the vessels that enter the leaf from the stem are seen to cut abruptly across the base of the young flower-bud. Even the vessels of the leaf, however, may be observed to be but imperfectly formed. They consist for the most part of cords of sclerenchyma with only occasionally one or two minute spiral vessels.

MANIFESTATIONS OF DISEASE.

74. ***Nucleated cells within the Pitted Vessels.***—I have gone into the details given in the last chapter, because it seemed necessary in order to follow the probable course of the disease that the study should start from some knowledge of healthy tissues. Mention has been made (*Para.* 6) of remarkable nucleated cells seen within the pitted vessels. Without venturing here to express any definite opinion as to the nature of these organisms, I would remark that I have not found them invariably present. Trees have been brought me as diseased in which I could find neither the nucleated cells of the pitted vessels, nor any of the other morbid conditions to

Conf. with Plate II, figs. 4 and 5.

NUCLEATED CELLS.

be described. And again, other trees have been examined by me in an advanced state of decomposition, but in which I failed to find the nucleated organisms within the pitted vessels. But, on the other hand, I failed also to discover a plant which, from external manifestations, might be described as intermediate between the two extremes indicated, that did not show a large percentage of its pitted vessels more or less completely obstructed with these organisms. In certain advanced stages I also recorded the existence of nucleated cells within the spiral vessels, and I thus became fairly convinced, after a very extensive series of observations, that their disappearance from the pitted vessels was coincident with the appearance of other abnormal conditions within the trachea, tracheides and spiral vessels.

75. When witnessed within pitted vessels that are only partially filled, *the organisms that have been spoken of as nucleated cells are* at first perfectly spherical. (See the two pitted vessels in the centre of *Plate I., fig. 1.*) They seem to be produced from the inner wall of the vessel and to be *surrounded by a remarkably thin cell-wall.* When fully developed, however, they become very large, considerably larger, as Mr. George Massee of Kew remarked to me (on his examining my microscopic sides), than the spores or cells of any known fungus. As they enlarge, the nucleus becomes distinctly visible *in each cell, and on the cells from opposite sides of the vessel* meeting they lose their spherical form and become closely compacted together. They are quite transparent, so that by turning the fine adjustment of the microscope, others, and still others, are brought into view as observations is carried down the vessels.

The micro-photographs (*Plate II., figs. 4 and 5*) show these remarkable and very large cells completely filling up a pitted vessel.

76. ***Plasmic coating.***—It will be recollected that the old pitted vessels contain air; that *in exceptional conditions only do they possess* fluids; and that, so far as is known, they have rather a structural than a vital *rôle* in the economy of plant life. It would, however, be contrary to all experience to suppose that these vessels could be completely filled up with foreign organisms, in the way shown by the photographs (*Figs. 1, 2, 4 and 5*) without the life of the plant being thereby seriously disturbed Moreover, plants in a further *stage* have been repeatedly seen by me to manifest a very different condition of pitted vessels. The internal walls of these vessels have been observed to be coated with a thick yellow brown layer that manifests

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PLASMIC COATING.

a slightly granular condition, but is not built up of cells or other recognisable organisms.

77. Coincident with this change in the pitted vessels the surrounding tracheides have been observed to be filled with a dark-brown substance, and a few, or, in advanced stages, all the spiral vessels, similarly entirely choked up with a thick yellow-brown plasmic deposit that in longitudinal section may be traced along the vessels as interrupted blocks of various lengths. This condition is seen in the micro-photograph (*Plate II., fig.* 6) of a transverse section showing the spiral vessels and xylem cells of a bundle filled with such deposits.

78. In time the walls of the pitted vessels of the tracheides and of the spiral vessels become absorbed, and the entire xylem is thus converted into a large irregular tube, the circumference of which is then seen to be lined with the thick yellow-brown (and, in advanced stages, reddish-brown) plasmic substance already mentioned.

The micro-photograph (*Plate III., fig.* 7) shows the xylem of fibro-vascular bundle destroyed, but with a few fragments of the spiral vessels floating in the long irregular channel and with the half-absorbed pitted vessel pressed against the phloem.

79. ***Xylem destroyed.***—It may also be noted (*fig.* 7) that the phloem is not seriously involved in the destruction, and that quite near are two perfectly healthy fibro-vascular bundles, one of which shows a very large pitted vessel which does not contain nucleated cells. This bundle also very beautifully exemplifies the inner sclerenchymatous layer of the bundle-sheath, separating the phloem from the immensely developed parenchymatous outer layer of the sheath.

But the destruction of the xylem, it will be observed, has extended downwards and obliterated the whole of the lower portion of the bundle-sheath. The adjacent cells of the fundamental tissue around the bundle have also been discoloured, their contents contracted and their nuclei have disappeared. These cells have, in fact, been converted into store-houses of reserve material to be used up with the progress of the disease. The transverse section of a diseased fibro-vascular bundle, as seen under the microscope, might thus not inaptly be compared with a great open ulcer.

80. ***Gemmation.***—Within the ulcer-like opening formed through the absorption of the vessels and the amalgamation of the yellow-brown deposits formerly contained within these, I have repeatedly seen spore-like bodies developed from the plasmic beds of

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DESTRUCTION OF XYLEM.

yellow and brown matter. These were thrown off from chains of similar bodies by a process of gemmation. I have called these spore-like because I failed to detect in them the nucleus, so strikingly present in the early stages of the disease. (*Plate III., fig. 8.*) They measured $\frac{4}{1000}$ths of an inch in length and a little more than half that in breadth. They were seen to be globular bodies often borne upon rather stout peduncles. The chief points of interest would seem to be that in no case did I find these so-called spore-like bodies in association with nucleated cells within the vessels But in every instance, where I did discover them, the cellular tissue for a considerable distance around was highly charged with transparent minute spherical bodies which I shall call sporules. These ranged from $\frac{1}{3000}$th to $\frac{1}{4500}$th part of an inch in diameter. The cell contents had also contracted or entirely disappeared. The so-called sporules were also seen to be reproduced by gemmation and to emerge from the cells by rupturing the cell-walls.

The following sketch may be given as conveying the appearance of these so-called spores and sporules greatly magnified as seen in longitudinal section through diseased fibro-vascular bundles:—

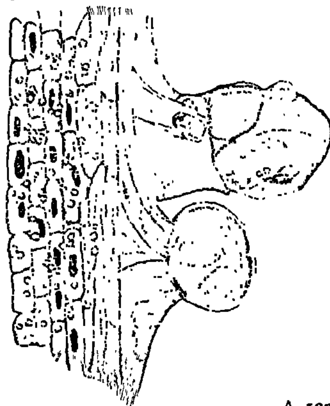


FIG. 10

Shows the sporelike formations within the xylem and sporules in adjacent cells.

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SPORES AND SPORULES.

The micro-photograph (*Plate III., fig. 8*) shows the so-called spores within a transverse *section of a diseased and obliterated xylem* of a fibro-vascular bundle.

The yellow and red tints of these formations rendered it next to impossible to photograph them; it was on that account that I made a drawing with the camera-lucida of the longitudinal section (shown in *fig. 10*). The transverse section (*fig. 8*) manifests, however, all trace of the fibro-vascular bundle obliterated and some three or four spore-like structures growing inwards from the wall of the irregularly shaped cavern that has taken its place.

81. I was unable to establish any direct connection between these spore-like bodies and the nucleated cells that had preceded them, but I have little doubt in my mind that they are connected, and that the so-called nucleated cells may be but an earlier stage. But if this view be not confirmed, there would seem no doubt that the distribution of small transparent sporules or vesicles through the tissue of the plant is directly connected with the production of a plasmic lining to the vessels and the formation on its surface of the structures I have spoken of as spore-like bodies borne on stout peduncles. At the same time, however, I obtained indications that the formations of these sporules may not be entirely dependent on the existence of my so-called spore-like bodies.

Vesicles.

82. ***Minute Sporules or Vesicles within the Tissues.***—In badly affected parts the contents of the cells of the fundamental tissue will be seen to have become contracted and reduced to flat solid structures not unlike minute plasmodia and that all traces of their nuclei have been lost. The cell-walls may also be observed to be perforated, so that it is clear a foreign influence has been passing from cell to cell. At a certain stage in this disintegration it will be discovered that minute round clear sporules or vesicles are formed from the plasmodial cell contents, and that these at once commence to gemmate and throw off smaller sporules. They may also be witnessed to pass through the cell-walls and to accumulate in the normal or within artificially formed intercellular spaces—spaces formed through the complete destruction of cells that have already discharged their sporules. This destruction will, on longitudinal section, be seen to very frequently follow the line of the fibro-vascular bundles, though ultimately it extends through the tissues irregularly.

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DESTRUCTION OF TISSUES.

The micro-photograph (*Plate III., fig. 9*) shows one of these irregular caverns penetrating through the tissue. It has involved two rows of cells at one part and three at another. Unfortunately the photograph does not bring out the multitude of transparent sporules packed within the cavern and oozing through the cell-walls. It shows, however, very clearly the discolouration and contraction of the cell contents into what I have called plasmodial-like thick dark-brown patches.

83. The following drawing made by means of the *camera-lucida* represents a similar cavern magnified 220 diameters. The sporules are there shown within the cavern, some of them undergoing gemmation. The ruptured cell-walls may also be witnessed as projecting within the cavern.

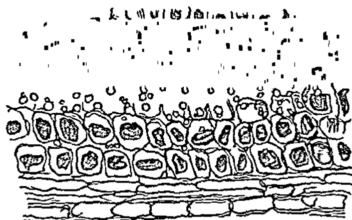


FIG 11.
Cavern filled with sporules or vesicles.

Fig. 12 represents a photographic enlargement, to four diameters, of a micro-photograph (×220) of a portion of a similar cavern to fig. 11. The drawing shows the contents of all cells contracted and darkened to the greatest extent remote from the cavern. One of the cell-contents is seen to bear a completely formed sporule (although the cell-wall would seem to be quite intact), while within the cavern numerous chains of sporules are visible.

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Microscopic Examination

DESTRUCTION OF TISSUES.

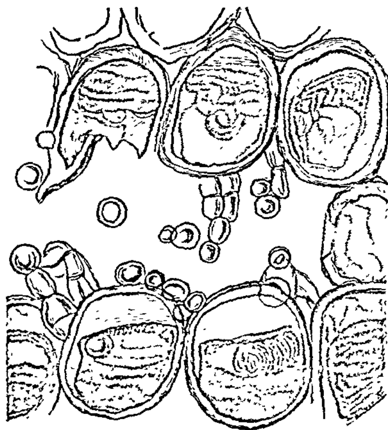


FIG. 12.

Sketch of portion of Cavern (× 220) with gemmating vesicles, enlarged photographically to four diameters.

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It may be useful to exhibit a transverse section (*Fig. 13*) through the structures permeated with sporules. These minute bodies will be observed to be in some instances within the cells and free, at others arising as it were from the contracted contents (x. x. x.) while in still a third condition they have escaped into large irregular intercellular spaces (*a*, *b*, *c*, *d*). In one of these intercellular spaces (*a*) a large spore-like body borne on a strong peduncle will be noted.



Fig. 13.

Destruction of fundamental tissue by sporules.

But in *no instance* are the sporules seen to be formed like hernia from the cell-walls They are fully formed before they attempted to penetrate through the pores or ruptured openings of the cell-walls.

84. *Under paragraph 65 a brief account has been given of the* upper epidermis and cuticle of the leaf-sheath. This has a somewhat curious bearing on certain further particulars that have now to be recorded. It is very commonly the case that a waxy looking substance is found spread out irregularly over portions of the base of the leaf-sheath but upon *the inner surface only*. The first stage in the extravasation of this waxy matter appears to be the formation of minute glistening blisters, which coalesce and then dry into the waxy brown coating. Beneath this external formation the cells of the leaf-sheath are invariably found to be discoloured and to have their contents contracted into flat thin plasmodia-like structures.

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EXTERNAL DEPOSITS.

But the cuticular layer of the leaf-sheath being composed of long and closely compacted cells seems to resist the action and the discoloration accordingly passes in an arched manner towards the epidermis, enclosing thereby portions of the cuticle that remain more or less unaffected. Assuming that the external deposit is derived from the tissue of the leaf-sheath, the passage toward the surface would thus seem to be made through the fibro-vascular bundles that every now and again arch acutely toward the surface. I failed, however, to find either the external deposits or the subtended discolorations of the cellular tissue, on the outer surface of the leaf-sheath, a circumstance that it is difficult to account for, seeing that on that surface the bundles come close up to the epidermis.

85. ***Thick-walled Cysts.***—In many cases also it was observed in tissues adjacent to the condition just described that instead of forming flat biscuit-looking structures, the cell-contents had become transformed into large perfectly spherical bodies that might be spoken of as resembling thick-walled cysts. But it was by no means an unusual occurrence to find one of these dark brown and sometimes bright red cysts to have its contents arranged into 2, 4 or more daughter cysts, or to discover cells that had burst and discharged their cystic contents.

86. On several occasions I placed sections with the cells charged with these so-called thick-walled cysts, under continuous microscopic observation—the sections having been prepared in sterilised distilled water. In a few hours they lost their colour and seemed to disappear. I failed, however, to discover their assuming an amœboid plasmodial condition, but in every case the fluid around the sections was shortly afterwards seen to be alive with a fermentative germ, probably Bacterium Aceti.

87 ***External Deposits.***—These observations led me to examine with considerable care the waxy exudation described above. A few of the young glistening blisters already mentioned were pricked with a fine needle, and the substance thus removed was communicated to a drop of distilled water It was then found to be literally alive with thousands of a minute elliptic-oblong unicellular Alga. The older plasmodial-like exudation was also examined. It was seen to be very hard and tough, in advanced conditions turning black and resembling pitch. On the surface what looked to the naked eye as a crystalline deposit was repeatedly noted. A scraping with a needle proved this, however, to be made up of great colonies of the

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INOCULATIONS.

Alga already mentioned. After being in water for some time these seemed to have all given origin to smaller and more circular cells and the liquid was also seen to swarm with the Bacterium already recorded. (*Conf. with 96—2*).

88. ***Inoculations.***—In order to obtain some indication of a connection, if any, between the two sets of observations recorded, *viz.*, observations in (*a*) the fibro-vascular bundles, and (*b*) in the cellular issue, I next proceeded to inoculate, under the microscope, sections of healthy betel-nut tissue which were kept under continuous observation. I also placed in sterilised distilled water cultivations in test tubes consisting of thin sections and also large pieces of healthy betel-nut tissue, one set inoculated with portions of fibro-vascular tissue showing the spore-like bodies (*Para. 80*) and others with cellular tissue showing sporules (*Para. 82*) In no case was I able to produce the diseased conditions. Nor in fact was I able to cause the healthy cells to have their cell-contents discoloured and contracted in the manner described. But when I inoculated healthy tissue with the Alga and Bacterium found in the external deposits (*Para. 87*) the tissues were rapidly destroyed.

I also experimented with a number of healthy betel-nut palms growing in flower-pots. I inoculated these in every way I could think of from diseased trees, but I failed absolutely to communicate the disease to them. These latter experiments were conducted for some time and now after four years the plants so treated are as vigorous as ever and have given not the smallest suspicion of having become diseased.

These results were naturally both most surprising and disappointing. I had witnessed hundreds of acres of palms killed outright by a disease that I could neither produce laboratory cultures of nor communicate to healthy plants.

89. ***Offensively Smelling Fluid.***—I have hitherto only attempted to detail what I saw, 'and there is a further circumstance that should accordingly be mentioned. It will be recollected that badly diseased trees were often found to contain a large amount of an offensively smelling fluid within the leaf-sheath (tubular chamber) and that this was produced by the decomposition of the terminal bud. This fluid was found to be literally packed full of large elliptical semi-transparent bodies, very similar to those I have designated as algal cells seen in the waxy exudation. An ordinary sized tree might easily

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OFFENSIVELY SMELLING FLUID.

contain a pint of the fluid referred to, and the point of a needle dipped into it would suffice to bring up many thousands of these organisms.

90. *Bacterium in Association.*—There is one other circumstance that I think it necessary to add, namely, that, in the fluid just mentioned, I found in great profusion a **Bacterium,** possibly **B. Aceti.** It was, moreover, almost impossible to prepare any microscopic sections of betel-nut tissue, without these energetic organisms being found dancing about everywhere. They are doubtless the putrifactive agents that bring about the final destruction of the tissue. It seemed fairly certain from my study of the Bacterium that it very possibly has no other relationship, and that it is to the Bacterium that the offensive smell of the fluid and of the decomposing tissues is due. (*Conf. with para. 96.*)

91. *Summary.*—By way of summing up these remarks it may be said that the sporules, found within the tissue, were most prevalent in the young leaf-sheaths and were only occasionally seen in the stem. That the deposits within the fibro-vascular bundles were more abundant in the chief bundles of the leaf than in the minor ones and more frequent in the older leaves than in the young ones. Similarly, they were more often seen in the well-formed bundles of the stem than in the immature ones. If it be accepted that the particulars already detailed give sufficient ground for supposing that there is a direct connection between these pathological conditions, then it might be reasoned that the trees are literally starved. The xylem of the more important bundles being filled up with foreign organisms that presumably use up the crude sap, the top portions of the stem (the inner buds and leaves) would naturally suffer first since these being young and growing require a larger supply of nourishment than the older, and nearly mature, leaves and buds. The circumstance that the disease does not attack simultaneously all fibro-vascular bundles may be accepted as explaining the somewhat erratic way in which certain pinnæ (*Para. 35*) of the leaf are seen to wither while for a time others remain green.

In part support of these conclusions I need hardly perhaps repeat that the location of disintegration within the topmost portions of the stem was most striking. It was not an unusual occurrence to find the terminal bud with all its leaves completely decomposed, whereas, two or three inches below, the stem was found comparatively healthy

looking, or to only manifest a few fibro-vascular bundles with deposits within their vessels.

92. But, I wish to reiterate the opinion I have already expressed, namely, that, in order to trace out the history of this very remarkable and alarming disease, it is essential that the study should be commenced in November or December. I have failed to verify some of my observations by actual inoculations, possibly owing to the fact affirmed by the betel-nut cultivators that the disease had reached its inactive stage by the time I was deputed to investigate it. I have, therefore, attempted to detail what I saw, not what I have proved. I have done so in the hope that my observations, and even speculations, may direct the attention of others to certain features of the disease, or, at all events, to certain morbid formations that are in intimate association with it. These should be demonstrated as unconnected with the disease or as only secondary consequences of it, if that be so; but I personally am strongly disposed to think that the complete obstruction of the xylem is quite sufficient to account for the subsequent destruction of the palms. The growing parts are thereby starved and death rapidly supervenes. This is instantly accompanied by the fermentative Bacterium and the Alga already described when the disintegration of the tissue and the production of an offensively smelling fluid is the natural consequence.

RÉSUMÉ OF IMPORTANT OBSERVATIONS.

93. ***Climatic Conditions that Favour the Disease. Review of Facts stated.***—I have demonstrated my failure to detect the presence of any parasitic organism. On the other hand, in paragraph 7, I have shown that the buds within the terminal closely embracing leaf-sheaths were always most diseased. This might possibly be accepted as denoting the absence of any external infection. Paragraph 25 points out that the soil of the great betel-nut area is very little above inundation level and for a considerable part of the year the roots accordingly may be regarded as practically standing in water. The rainy season may be said to terminate in October. The level of the rivers then rapidly falls and the soil gets dried up. But there is usually a little rain in January. When this fails and the hot season approaches, the soil becomes abnormally dry and parched. At the same time the atmosphere is rendered extremely dry and hot. Excessive transpiration Climatic Conditions.

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RESUME.

ensues and the demand for moisture from the soil becomes very great.

Rain fell in April and May of 1896 and the disease was recorded to have at once abated. The soil was moistened and the atmosphere had its temperature lowered and its humidity raised.

Sub soil moisture.

Paragraph 26 points out that one belt of betel-nuts was observed to be free from disease, while several other plots not very remote were practically destroyed. But the healthy plot was in close proximity to a stream, whereas the diseased plots were remote from water. This circumstance may be accepted as denoting the necessity for sub-soil moisture in betel-nut cultivation. Plots of betel-nut of, say, from 5 to 40 acres each have one or several tanks in the middle or here and there (*Para. 17*). During my tour through the betel-nut area the cultivators invariably pointed to the circumstance that their tanks were either dry or so low that they were useless. This circumstance may be accepted as pointing to the necessity of water at the roots of the palms during the hot months.

Favourable Conditions.

Paragraph 29 shows that it is believed the disease prevails more in dry than in wet weather, and that it very often follows abnormal climatic conditions. Rain in fact was universally admitted as checking the disease, but if once started there would appear to be only a temporary cessation of activity through the fall of rain, the disease returns again with the succeeding hot weather. It would thus appear that the conditions that favour the initial production of the disease do not frequently prevail, but that when once started the disease continues for several years, being renewed by climatic conditions that would not suffice to originate it.

Paragraph 35 deals with the fact that while the actual bud within the terminal leaf-sheaths may be completely decomposed, only the second or it may be the third leaf below gives indications of the presence of the malady. This might be regarded as due to the nucleated cells (*Paras. 6 and 74*) finding readier ingress to the more fully developed bundles of these leaves. The terminal bud may be supposed to be thereby completely cut off from supplies of crude sap.

Transpiration from *Leaves*.

Paragraphs 48 to 53 demonstrate that vigorously active decomposition is at first confined *to the young growing parts of the stem*. On the other hand, paragraph 64 may be accepted as pointing to the probability that the stomata of the betel-nut leaf favour a high

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transpiration in normal seasons, but would very possibly be ill adapted to abnormal draughts.

Paragraph 74 deals with the circumstance that the nucleated cells are not invariably present. They are in fact nearly always absent *in advanced stages. It is thus probable that the obstruction of the* pitted vessels may so interfere with the life of the palm as to give origin in rapid succession to the other and more destructive conditions already detailed.

Constitutional Disease.

I have suggested that the betel-nut plague may in reality be viewed as far more of the nature of a constitutional malady than of an infectious or contagious disease. And this is the opinion which I venture to think must be upheld. It is clearly originated by climatic conditions and conditions that do not occur frequently. Within the memory and traditions of the cultivators there have been one or at most only two previous out-breaks during the past 100 years.

PROBABLE NATURE OF THE DISEASE.

94. ***Probable Explanation.***—There would appear to be little doubt the disease is due to a pathological condition that has come to be known as Tyloses. Briefly this may be described as the destruction of the vascular by means of the fundamental tissue of the plant, a condition brought about by certain unfavourable climatic states.

The origin of the name Tyloses seems to be unknown. The pathological condition indicated, we are told by Sir William T. Thiselton-Dyer (*Journal of Botany, Vol. X., (1872), pages 321-23*), was first mentioned by Malpigi (1686) in his *Anatome Plantarum* (*Vol I., tab. 6*) as seen in the oak. The next paper on the subject would appear to have been an anonymous article in the *Botanische Zeitung* for 1845, supposed to have been written by the Baroness Hermine von Reichenbach. In this paper the cells seen within the pitted vessels are designated Thyllen. Mohl (in the *Ray Society's* Volume for 1849) published his Memoir on the Palm Stem. He there alludes to having witnessed "Vesicular Cells" in the pitted vessels of Corypha cerifera. He then adds, "I have not traced the development of these cells in the palms. Doubtless they have the same character as in Dicotyledons, in regard to which, from recent researches, * I think that I am not wrong in assuming that they are

* Doubtless the Baroness von Reichenbach's paper that described the condition seen in the Vine, etc.

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produced by a protruding expansion (a kind of hernia) of the adjacent cell, which penetrates the pore, and either tears through or causes the absorption of the primary membrane of the vessel."

I do not propose to discuss the entire literature of this subject, but think it sufficient to quote another passage from Sir William Thiselton-Dyer's most admirable review. He writes, "For some information about two other papers on the nature of *Thyllen*, I am indebted to my friend Mr. Archer of Dublin; and as I am unable at the present time to examine these papers in detail, I shall take the liberty of using what he has told me about them. The first is by Bohm,* who appears to have held, according to the account of the next mentioned writer, that the so-called *Thyllen* do not originate by bulging out of the cells surrounding the ducts, but by accumulation of *plasma* between the *lamellæ* of the walls of the vessels whose innermost layers grow out as the membranes of the *Thyllen* cells. These views have been combated by Reess in the *Botanische Zeitung* for 1868 (pages 1-11). According to him "Each young *thylle* makes its appearance as a bulging of a wood-parenchymatous or medullary-ray cell forced through a pore in the vessels." Sir William Thiselton Dyer then adds, "Reess's views and figures are quite consonant with what has been stated by Mohl and described and figured by the Baroness von Richenbach. According to Reess, the communication between the *thylle* and the mother cell persists for some time, the *thylle* growing considerably, becoming filled from the contents of the mother cell, and not rarely forming a secondary nucleus. The *thyllen* are finally shut off from the mother cells, and Reess supposes their object to be the storing-up of starch, which appears to me a somewhat doubtful hypothesis." (*Conf. with paras. 58 and 60 a.*) Sachs (Lectures on the Physiology of Plants, translation 1887, page 851), speaking of the parenchymatous tissue found within the vessels of Dicotyledons, says that the cells seen "arise in fact by the very thin closing membranes of the bordered pits, at the spots where the vessels abut on soft parenchyma cells, becoming forced into the cavity of the vessel under the turgescence of the latter, and then beginning to grow vigorously. A club-shaped vesicle is thus formed which, as it grows, undergoes cell-divisions, and when such structures protrude from numerous pits, they fill up the cavity of the vessels and compress one another, and thus produce a parenchyma-like tissue."

* Sitzungsber., K. K. Akad. d. Wissensch, Vienna, 1867.

TYLOSES.

It may be added in concluding this brief abstract of the opinions, already published, regarding **Tyloses**, that several writers have described the prevalence of this pathological condition in the fossil woods of the Eocene period, and one author is even supposed to have seen it in a non-gymnospermous fossil wood from the Lias.

95. *Tyloses as a Serious Disease.*—Writers on the pathological state that has come to be known as **Tyloses** have spoken of it, however, as a remarkable condition that is known to occasionally occur or which may even be experimentally brought about. But it would appear that the Bengal plague in the betel-nut palms is the first record of this extraordinary suicidal degeneration having assumed the condition of a serious malady. It is usually affirmed that that condition is brought about during an abnormally rapid production of fundamental tissue. Excessive stimulation by water (at the roots of the plant), while the leaves are exposed to a very dry hot atmosphere, are the conditions supposed to be most favourable to the production of **Tyloses**.

It is customary to demonstrate this action by a glass tube having a few lateral holes cut through it. Within the tube a soft India-rubber bag, filled with water, is placed. So long as no pressure is exerted, the bag rests within the tube, but if pressure be communicated on the top and bottom, hernia-like prolongations emerge through the lateral perforations. The India-rubber bag is supposed to represent parenchymatous cells which, owing to an abnormal necessity, commence to grow and multiply. Finding least resistence by pushing through the pores of the pitted vessels they make their entrance and soon literally fill these vessels.

It may have been observed during perusal of paragraphs 74 to 87 and by contrasting these with paragraph 94, that there are certain points in my observations that seem to differ from the views hitherto published by writers on this subject. It may perhaps be helpful therefore if I exhibit some of these differences categorically:—

(*a*) I have never actually detected a nucleated cell in the act of passing through the pits of the vessels, that is to say, I have never been so fortunate as to detect a cell visible both inside and outside the vessel.

(*b*) In the early stages the nucleated cells may be seen as perfectly spherical in shape and appear, as it were, to ooze out of the substance of the walls of the vessels. (*Para. 75.*)

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TYLOSES.	(*c*) They exist for a considerable time as perfectly transparent cells and neither seem to possess cell-contents nor a nucleus. (*d*) As they enlarge and come into contact with each other they assume any and every shape, have very thin semi-transparent contents and a large nucleus with often also a distinct nucleolus. (*Para. 75.*) (*e*) As already stated I have not been able to prove that these nucleated cells directly originate the subsequent pathological manifestations, but this much I think may be affirmed as certain, *viz*, that the nucleated cells gradually disappear as the other conditions come into existence. (*Para. 74.*) (*f*) The inner walls of the pitted vessels as also of all the other vessels of the xylem gradually become lined with a plasmic-like substance, at first pale-coloured, then yellow, next red and finally so dark red as to be almost black. A little later the vessels themselves are ruptured and torn to pieces. The plasmic substance is then seen to line the interior of the irregular longitudinal burrow thereby produced. (*Paras. 76-78.*) (*g*) From the inner surface of this thick coating, short stout peduncles are produced that ultimately bear fairly large spherical cells. These are nearly transparent and do not possess a nucleus. By gemmation they in time give birth to chains of smaller and still smaller cells. (*Para. 80.*) (*h*) The parenchymatous tissue immediately adjacent to such complete destruction of the xylem, as I have indicated, cannot be said to invariably nor even to any very special degree, manifest the destruction by Tyloses that might be anticipated. (*i*) But the cells of the adjacent tissues have their contents discoloured, contracted and their nuclei have invariably disappeared. (*Para. 82.*) (*j*) Turning now to the condition met with in the fundamental tissue. In no instance was I able to detect a hernia-like protuberance from the cell-wall, such as has been described in the Tyloses of Dicotyledons. (*Para. 94*) In every instance the minute vesicles (or sporules as I have called them), that are formed in the parenchymatous tissue, were seen to originate from the contracted and discoloured cell

TYLOSES.

contents. They have their cell-walls complete before they rupture and pass through the mother cell-walls. (*Para. 82.*)

(*k*) It was occasionally observed that a sort of cell-division took place, the contents being split up into two, four or more almost spherical portions and that these became possessed of separate cell-walls before the mother-cell ruptured to allow of their escape. (*Para. 85.*)

(*l*) The discoloured cell contents seem to be identical both with the lining mentioned above, as seen within the vessels and with the plasmodial-like external substance mentioned (*Para. 84*) as found on the leaf-sheath.

96. ***Gumming of Sugar-canes by*** **Bacillus vascularum.**— While engaged reading the final proof of the above observations on the Betel-nut Plague, my attention was accidentally directed to Dr. N. A. Cobb's most interesting account of the disease of Sugar-cane, seen by him in the Lower Clarence River plantations of New South Wales. Dr. Cobb appears to have arrived at the conclusion that the diseased condition in question, and to which he assigned the name of "Gumming," was due to the agency of a Bacillus for which he proposed the name of B. vascularum. Dr. Cobb published in 1893 the facts known to him of that disease in a pamphlet entitled the "Diseases of the Sugar-cane" which was one of a series of papers designated, *Plant Diseases and their Remedies*, issued by the Department of Agriculture, Sydney. I have not been able to discover any further particulars, but doubtless much progress has been made in the study of that curious disease.

Dr. Cobb gives most instructive particulars as to the method he pursued in inoculating healthy canes with the Bacillus. He seems also to have been perfectly satisfied with the results obtained and has, therefore, no hesitation in regarding the diseased condition as due to the presence of Bacillus vascularum.

There is so much in common in the general symptoms and pathological lesions of the tissues concerned in the "gumming" of sugar-cane and the "plague" of the betel-nut palm, that I have thought it desirable to give here a brief notice of Dr. Cobb's investigations and to quote the pages in his pamphlet and paragraphs of this report (above) where closely analogous conditions have been denoted :—

1. When the sugar-cane is gummed badly the tops are seen to be dead. "The base of the arrow in such cases will be

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GUMMING OF SUGAR CANE.	found to be rotten, and usually one or more cavities of considerable size are to be seen near the top of the stalk, filled or partially filled, with offensive matter." (*Page 5.*) (*Compare with paras. 48-55 above.*) 2. If a stalk which has died at the top in the manner described, be cut into pieces with a sharp knife in such a manner as to leave the cut surface quite smooth, a honey-coloured gummy matter will, in a few minutes, be seen to ooze slowly out and form in droplets on the ends of the cut fibres. This gum is sometimes nearly transparent, sometimes rather opaque, and varies also in colour from nearly colourless into various tints of yellow according to the stage reached by the disease. (*Page 5.*) (*Compare this with paras. 77-78, 84-87.*) 3. "A microscopic examination of a thin slice across a gummed cane shows at once that the disease is not general but local. The gum, except in certain cases, is confined to the fibres; in fact, to the sap-vessels, the latter being plugged up with gum." "This confinement of the gum to the sap-vessels is one of the most striking microscopic features of gummed cane. In advanced cases, and in the more tender tissues at the top of the cane, the gum is not so local in its distribution; it may, under such circumstances, be found outside the fibres." (*Pages 8-9.*) (*Compare with paras. 74-79 also 94-95*). 4. Dr. Cobb found in the fresh "gum" a microbe which he recognised and figured as Bacillus vascularum (*pages 9-10*). I failed absolutely to prove that the Bacterium seen by me could be in any way whatsoever the cause but was in all probability only a consequence of the disease. Inoculation with the Bacterium on healthy betel-nut palms failed entirely to produce either the symptoms or the pathological lesions of the plague. (*Compare with para 90.*) 5. Lastly, Dr. Cobb, while suspecting that the disease might be found to be more general than was known for certain, goes into some details regarding the climatic conditions, soil, etc., of the Lower Clarence River plantations (*pages 12-14*). "Gumming," he adds, "at present prevails on the farms

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below Maclean. Why is this? It is not, so far as I could observe, because of any inferiority in the cultivation down river. I believe that our question is answered by the fact that the land in the lower part contains more—that is, too much—moisture." (*Compare with paras. 90, 95, 98.*) RESEMBLANCE TO BETEL-PLAGUE.

It may thus be admitted that the above and other circumstances that might be mentioned though striking and curious in no way prove that the two diseases are the same. I have accordingly ventured to draw attention to Dr. Cobb's most instructive paper mainly with a view to its becoming suggestive of lines of enquiry that might be dealt with in future manifestations of plague in the Betel-nut Palms of India.

97. ***Conclusions.***—It will thus be seen that my observations coincide more with those attributed to Bohm than with the views advanced by the Baroness von Reichenbach, by Mohl, Reess, Sachs, etc There seems a probability, however, that, with the exception of Mohl's brief remarks, the present is the only study of the form of Tyloses met with in palms, hitherto published. And it is significant that Mohl appears to be the only writer on this subject who has led special stress on the circumstance that in the course of development the Thyllen rupture the vessels. In the passage quoted above it will be seen that Mohl's words are that the Thyllen are produced by a "protruding expansion of the adjacent cell, which penetrates the pore and either tears through or causes the absorption of the primary membranes of the vessels." The plate which is given in the Journal of Botany in illustration of Sir William Thiselton-Dyer's paper shows both large cells within the vessels and smaller vesicles, but no description is given of the latter. According to my observations it is the minute vesicles that are the agents of final destruction. Conclusions.

Not only are the vessels of the xylem ruptured, but the so-called sporules or vesicles that appear in the fundamental tissue soon produce great caverns and rapidly effect the complete destruction of all the tissues. At this stage fermentative and other saprophytic organisms find a way into the young growing parts and in a few days the terminal bud and all the young leaves become reduced to an offensively smelling pulp and milky fluid. After the terminal bud has fallen to the ground the destruction extends down the stem

AREGA Catechu	Probable Nature of the Disease
GUMMING OF SUGAR CANE.	found to be rotten, and usually one or more cavities of considerable size are to be seen near the top of the stalk, filled or partially filled, with offensive matter." (*Page 5.*) (*Compare with paras. 48-55 above.*) 2. If a stalk which has died at the top in the manner described, be cut into pieces with a sharp knife in such a manner as to leave the cut surface quite smooth, a honey-coloured gummy matter will, in a few minutes, be seen to ooze slowly out and form in droplets on the ends of the cut fibres. This gum is sometimes nearly transparent, sometimes rather opaque, and varies also in colour from nearly colourless into various tints of yellow according to the stage reached by the disease. (*Page 5.*) (*Compare this with paras. 77-78, 84-87.*) 3. "A microscopic examination of a thin slice across a gummed cane shows at once that the disease is not general but local. The gum, except in certain cases, is confined to the fibres; in fact, to the sap-vessels, the latter being plugged up with gum." "This confinement of the gum to the sap-vessels is one of the most striking microscopic features of gummed cane. In advanced cases, and in the more tender tissues at the top of the cane, the gum is not so local in its distribution; it may, under such circumstances, be found outside the fibres." (*Pages 8-9.*) (*Compare with paras. 74-79 also 94-95*). 4. Dr. Cobb found in the fresh "gum" a microbe which he recognised and figured as Bacillus vascularum (*pages 9-10*). I failed absolutely to prove that the Bacterium seen by me could be in any way whatsoever the cause but was in all probability only a consequence of the disease. Inoculation with the Bacterium on healthy betel-nut palms failed entirely to produce either the symptoms or the pathological lesions of the plague. (*Compare with para. 90.*) 5. Lastly, Dr. Cobb, while suspecting that the disease might be found to be more general than was known for certain, goes into some details regarding the climatic conditions, soil, etc., of the Lower Clarence River plantations (*pages 12-14*). "Gumming," he adds, "at present prevails on the farms

below Maclean. Why is this? It is not, so far as I could observe, because of any inferiority in the cultivation down river. I believe that our question is answered by the fact that the land in the lower part contains more—that is, too much—moisture." (*Compare with paras. 90, 95, 98.*)

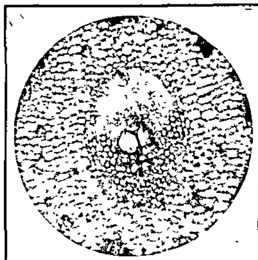
RESEMBLANCE TO BETEL-PLAGUE.

It may thus be admitted that the above and other circumstances that might be mentioned though striking and curious in no way prove that the two diseases are the same. I have accordingly ventured to draw attention to Dr. Cobb's most instructive paper mainly with a view to its becoming suggestive of lines of enquiry that might be dealt with in future manifestations of plague in the Betel-nut Palms of India.

97. ***Conclusions.***—It will thus be seen that my observations coincide more with those attributed to Bohm than with the views advanced by the Baroness von Reichenbach, by Mohl, Reess, Sachs, etc. There seems a probability, however, that, with the exception of Mohl's brief remarks, the present is the only study of the form of Tyloses met with in palms, hitherto published. And it is significant that Mohl appears to be the only writer on this subject who has led special stress on the circumstance that in the course of development the Thyllen rupture the vessels. In the passage quoted above it will be seen that Mohl's words are that the Thyllen are produced by a "protruding expansion of the adjacent cell, which penetrates the pore and either tears through or causes the absorption of the primary membranes of the vessels." The plate which is given in the Journal of Botany in illustration of Sir William Thiselton-Dyer's paper shows both large cells within the vessels and smaller vesicles, but no description is given of the latter. According to my observations it is the minute vesicles that are the agents of final destruction. Conclusions.

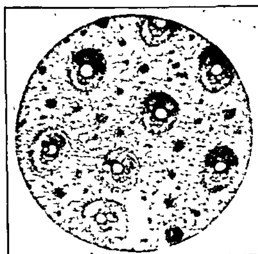
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1



Transverse Section of a Fibro-vascular Bundle (Para. 59).

2



Transverse Section of Leaf Sheath near Middle (Para. [illegible])

3

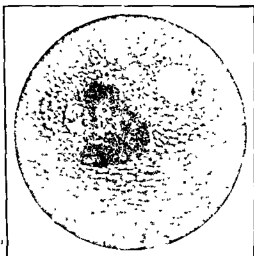


Nucleated Cells [illegible] Fitted [illegible] ×4[illegible]0.
(Para 74).

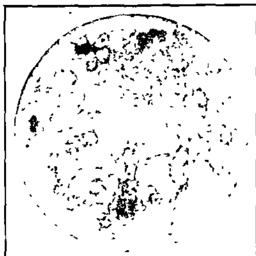
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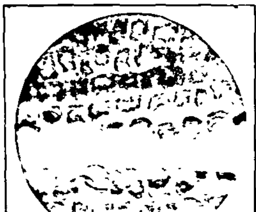
[illegible] cated Ce[illegible]s [illegible] ed [illegible]esse[illegible]s ×[illegible]

6



Xylem completely destroyed.
(Paras 75 & 79)





All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series, those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

THE AGRICULTURAL LEDGER.

1901.—No. 9.

TACHARDIA (CARTERIA) LACCA, *Kerr.*

(SYN. COCCUS LACCA.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. II., C. 1491-1511 also Vol. IV. (Lac), L. 1-18.*]

LAC (LAKH) AND THE LAC INDUSTRIES.

BY GEORGE WATT, M.B., C.M., C.I.E., etc.,
Reporter on Economic Products to the Government of India.



CALCUTTA:
OFFICE OF THE SUPERINTENDENT, GOVERNMENT PRINTING, INDIA.
1901.

THE

AGRICULTURAL LEDGER.

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INTRODUCTION. *Some Historic Facts.*

Europe first sought lac. The rich crimsons of ancient Greece and Rome, were doubtless derived mainly from the parasitic incrustations of an allied insect met with on a species of oak (which grows abundantly) in the South of France, in Spain, Italy, the Greek Islands and Candia. The red particles picked off the branches of that oak, prior to the introduction of Cochineal from Mexico, were spoken of as "grains" or "berries" and hence fabrics dyed with them were termed "engrained;" and ultimately, owing to these crimson dyes being fast "engrained," became a general term in the dye trade for fast colours The term *coccus* occurs both in ancient Greek and Roman literature. *Kermes (kirmij)*, its Arabic synonym, means a little worm. From *kermes* we have derived, through Italian and French, the word Crimson. In Latin, *vermiculus* (a name often given to it) means a little worm and from that, through the French, we have derived Vermillion, while later on from Lac (or Lakh) we obtained Lake. Lakh means 100,000, a name given to this substance in allusion to the legion of small insects that are seen to swarm at certain seasons.

The old names of Lac Dye and Lac itself have given origin to terms denoting colour.

It will thus be observed that the contributions to the English language, traceable to this substance and its allies, have all a direct allusion to the dye, not the resin, which lac affords. But from very ancient times in India the resin has been, and in modern commerce is, by far its most valuable property. In the *Ain-i-Akbari* a work often spoken of as the Administration Report for 1590, issued by the Great Emperor Akbar we read of the proportions of lac resin to be employed in the varnishes to be used for the wood-work of public buildings.

The resin more valuable in India than the dye

EARLY EUROPEAN WRITERS

2. *Earliest European writers.*—One of the earliest European writers on the subject of lac was a Dutchman, sent to India on a scientific mission by the King of Portugal, *viz.*, John Huyghen van Linschoten. The report of his explorations was published in 1596, and the first English edition of it in 1598 He gives full particulars as to the uses of the resin, but curiously makes no mention of the lac dye. He shows however that he had arrived at an absolutely erroneous notion as to the agency by which the lac-incrustations were formed on trees. Since his interesting account of this product [illegible] not be readily accessible it may be here given:—

Linschoten, 1596 A. D.

Assl (? for Lac).

"Lacke" by the Malabares, Bengal[illegible] [illegible]aniins, is called by the Moors Lac: the men of Pegu (w[illegible] [illegible] is found, and [illegible]

C. 1491-1511.

INTRODUCTION, Some Historic Facts.

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"Lacke" by the Malabares, Bengalers, and Decanins, is called Assi, by the Moors Lac : the men of Pegu (where the best is found, and most

C. 1491-1511.

EARLY EUROPEAN WRITERS.

trafiqued withall) doe call it Treck, and deale much therewith by

brought from thence into their countries. The manner how it is made

trees comes a certaine gumme, which the Pismires suck up, and then they make the Lac rounde about the branches of the trees, as Bees make Hony and Waxe, and when it is ful, the owners of the trees come and

better it is: the peeces and crummes that fall upon the ground, they melt them together, but that is not so good, for it hath filth and earth within it: it happeneth oftentimes that they finde the Pismires winges within the raw Lac. When the Lac is raw, as it commeth from the Tree, it is a darke red colour, but being refined and cleansed, they

the turning [melteth the waxe] so that it entreth into the crestes and cleaveth unto it, about the thicknesse of a man's naile then they burnish it [over] with a broad straw or dry Rushes so [cunningly] that all the woode is covered withall, and it shineth like glasse, most pleasant to behold, and continueth as long as the woode being well looked unto: in this sort they cover all kinde of householde stuffe in India, as Bedsteddes, Chaires, stooles, etc., and all their turned wood worke which is wonderful common and much used throughout all India the fayrest workemanshippe thereof commeth from China, as it may be seene, from all the things that come from thence, as Deskes, Targets, Tables, Cubbordes, Boxes, and a thousand such like thinges, that are all covered and wrought with Lac of all colours and fashions so that it maketh men to wonder at the beautie and brightnesse of the colour, which is altogether Lac They likewise use Lac to fill their Golde and Silver workes, that is to say, haftes of knives, and other things, which they make very fayre outwardly of Silver, and inwardly full of Lac. The Indians likewise are so cunning, that they make Ringes of Gold, which [to mens sight] seem [very] fayre and heavie, as though they were all of massy Gold, inwardly they are hollow and stopt with Lac, and cannot be perceived, unlesse a man bee advertised thereof. There is Lac likewise in Ballagate and Malabar, but [very] little the greatest quantitie which from thence is carryed throughout India, and all other places, commeth out of the Kingdome of Pegu."

It will thus be seen that Linschoten learned (300 years ago), very nearly every particular regarding the native use of lac, but from his

C. 1491-1511.

MATERIALS FOR THE PRESENT ACCOUNT.

article, an extensive correspondence has been conducted. Direct local information together with an invaluable series of samples, in illustration of the details narrated, have been procured practically from every district in India where a trade in lac or an industry in lac manufactures exists. But as most of these exceedingly liberal correspondents have of necessity traversed the same ground, it was found impossible to publish more than a small proportion of the communications actually received. The others have been of the greatest possible value in maturing or confirming the facts here given Where correspondents chanced to deal with methods or appliances not generally known, such portions have been stated under the names and addresses of the contributors.

Arrangement of the account.

It will be observed that the subject has been dealt with under certain chapters such as INTRODUCTION—A BRIEF HISTORY OF LAC AND LAC-DYE: INDIA'S EXTERNAL TRADE IN LAC. THE PRODUCTION AND CULTIVATION OF LAC: THE MANUFACTURE OF LAC AND LAC-DYE: THE CHEMISTRY OF LAC AND LAC-DYE: THE INDUSTRIAL AND ART USES OF LAC AND LAC-DYE. Within each of these chapters the effort has also been made to group information provincially. Commencing with Bengal and passing East and North, then turning West and South to Burma the provinces have been as far as possible taken up in the same sequence.

A special treatment was however found unavoidable for certain subjects such as the trees on which the Lac Insect feeds; the timbers used in Lac-turnery; and the pigments employed in colouring lac. These have been dealt with collectively and the information given on such subjects has (as far as possible) been removed from the letters that have been here published in other sections of this review.

CHAPTER I.

INDIA'S EXTERNAL TRADE IN LAC.

TRADE IN LAC. History of. 1792

4. *Export Trade.*—It is surprising that it took half a century very nearly for the properties of the resin to be fully appreciated in Europe. Indeed from the crude methods of manufacture that prevail at the present day, one can hardly escape the impression that shellac is to some extent even still viewed as but a bye-product; it is hardly regarded as the article which alone finds a place in modern commerce.

TRADE IN LAC.

Perhaps the earliest important reference to commercial transactions in this commodity is that which will be found in the Oriental Repertory, Vol. II, page 580, where Mr. Brown, Resident at Cossimbazar, wrote in 1792 that "If the Board shall think proper to send a few maunds of lac to Europe it can be procured in Calcutta." One of the earliest authentic records of the actual export trade in the substance will be found in H. H. H. Wilson's Review of the External Commerce of Bengal. That admirable report deals with the returns for 1813 to 1828. The following passage may be here given:—

Wilson, 1813 A. D.

"The export of lac-dye was long limited by the difficulty experienced in extracting the colouring matter, and applying it to manufacture at home. The high price of cochineal, however, stimulated ingenuity, and of late years the article has risen in demand. At first the value of the export was about two lakhs, from which it fell off to less than one lakh In 1820-21 it again rose, and in 1824-25 its value exceeded seven lakhs, which elevation it has since maintained. Its use as a dye, however, depends upon the scarcity and dearness of cochineal, for which it is employed as a substitute; and so little temptation exists to embark in the manufacture of it, that it is rarely prepared, except according to contract. The resinous portion of the lac, known as shellac, has also increased in demand in England, being exported thither to the amount of nearly a lakh of rupees for some years past." (*Asiatic Journal, 1831, p. 220.*)

J. E. O'Conor's Returns

5. At the beginning of the present century, therefore, the exports of lac-dye to foreign countries were some five or six times more valuable than those of the resin. Mr. J. E. O'Conor, C.I.E., Director General of Statistics, has furnished us with the figures of the modern foreign trade down to the present date. It may suffice to illustrate the tendency and character of these transactions if I quote here the returns for the past thirty years:—

Years.	Lac-dye.		Shell-lac.	
	Cwt.	R	Cwt.	R
1868-69	17,748	7,66,655	43,740	11,65,739
1869-70	20,864	9,26,072	54,548	12,75,401
1870-71	12,501	5,54,433	40,221	11,26,136
1871-72	17,463	7,81,169	57,820	16,18,042
1872-73	10,427	4,68,655	50,641	4,20,583
1873-74	9,907	4,45,612	65,790	18,41,491

TRADE I[illegible] LAC.

Years.	Lac-dye Cwt.	Lac-dye R	Shell-lac. Cwt.	Shell-lac. R
1874-75	8,385	3,76,340	67,701	18,95,281
1875-76	10,668	2,65,723	80,645	65,06,928
1876-77	19,051	3,78,556	89,880	42,20,497
1877-78	9,570	2,90,087	78,875	28,50,552
1878-79	8,261	1,95,285	64,498	22,24,843
1879-80	13,790	2,26,568	49,541	30,41,855
1880-81	6,304	1,30,201	60,842	43,16,267
1881-82	5,032	91,958	80,491	55,52,413
1882-83	3,927	46,104	102,871	55,47,619
1883-84	997	14,085	93,275	48,16,975
1884-85	106	1,274	106,747	45,36,326
1885-86	1,784	31,630	112,116	43,96,417
1886-87	915	16,188	115,137	40,16,127
1887-88	279	6,205	112,051	42,03,274
1888-89	334	8,038	81,390	31,94,125
1889-90	329	8,677	70,096	37,30,865
1890-91	163	5,018	112,496	59,48,599
1891-92	45	2,500	110,276	60,67,924
1892-93	249	10,090	102,079	64,38,513
1893-94	90	4,600	94,144	72,72,838
1894-95	402	26,025	131,367	1,14,76,706
1895-96	15	1,705	162,686	1,46,31,466
1896-97	*Nil*	*Nil.*	175,728	1,19,35,957
1897-98	*Nil.*	36	189,329	92,86,795
1898-99	6	200	146,395	70,07,781
1899-1900	1	24	195,239	92,65,600

Striking Peculiarities.

I have not dealt with button-lac nor with the unmanufactured forms of stick-lac and seed-lac, because the quantities of these exported are comparatively insignificant (total in 1899-1900; button 40,320 cwt.; stick and seed 2,888 cwt.). The figures as they stand in the above table exhibit therefore in a remarkable degree certain striking peculiarities:—

(*a*) The decline and practical disappearance of the export trade in lac-dye from close on eight lakhs of rupees worth in 1868-69 to R24 in 1899-1900.

(*b*) The steady growth of the shellac trade from (at the beginning of the period) R11,65,739 to R1,46,31,466 in 1895-96 and R92,65,600 in 1899-1900.

(*c*) The remarkable fluctuations in the amount of the exports within the past 10 or 15 years.

(*d*) The erratic disturbances in the value of the commodity.

C. 1491-1511.

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C. 1491-1511.

TRADE IN LAC.

The following passage may be here given as manifesting some of the early historic features of the trade in Lac.

Imports and re-exports of Great Britain in the early part of last Century.

6. *Extract from the Asiatic Journal for July 1827, page 212.*

"Account of the Quantity of Lac-Lake, Lac Dye, and Cake Lac imported into Great Britain from the East Indies in the last Thirteen Years; also the Quantities re-exported, charged with Duty for Home Consumption during the same period.—(28th May 1827).

Years.	Imported. lbs.	Re-exported lbs.	Paid duty. lbs.
1814	278,899	5,017	133,935
1815	598,592	8,441	137,915
1816	260,373	27,412	162,894
1817	384,909	23,091	234,763
1818	242,572	32,079	323,169
1819	179,511	21,707	207,063
1820	441,486	49,519	912,514
1821	641,755	91,925	322,837
1822	872,967	29,578	349,351
1823	534,220	13,050	414,714
1824	604,264	53,843	485,339
1825	541,443	61,908	385,734
1826	760,729	68,603	395,609

Countries importing lac from India.

7. *Countries to which exported.*—A further analysis of these returns reveals the fact that the United Kingdom has taken by far the major portion of the amounts.

In 1868-69, the United Kingdom took R8,82,020 and the United States of America secured R2,56,609 worth, out of the total R11,65,739. The corresponding figures for 1897-98 were, United Kingdom R40,22,914, and the United States R27,54,060 out of the total of R92,86,795; and from 1899-1900 they stood at R28,41,941 and R38,31,153 thus manifesting a great expansion in the demand from the United States of America. But a feature of the modern transactions which may perhaps to some extent be the result of the opening of the Suez Canal, *viz.*, the Continental supply that formerly used to go to London in the first instance, is now purchased by Calcutta agents and shipped direct to Continental ports. This difference in the course of the trade may be illustrated by the exports for the three following years:—

		Cwt.	R
1884-85	To United Kingdom .	68,654	29,02,301
	To United States .	21,152	9,53,644
	To Continental Ports .	15,413	6,10,854
1897-98	To United Kingdom .	82,291	40,22,914
	To United States .	53,698	27,54,060
	To Continental Ports .	51,069	23,07,907

TRADE IN LAC.

		Cwt.	R
1899-1900	To United Kingdom .	60,257	28,41,941
	To United States .	79,615	38,31,153
	To Continental Ports .	52,102	24,24,255

Internal trade of India.

8. ***Calcutta Transactions.***—An examination of the Coastwise traffic reveals the fact that Burma and Madras send large supplies to Calcutta. The rail-borne returns similarly manifest the fact that the Central Provinces constitute one of the chief sources of the article exported from India *vid* Calcutta. But Assam also sends a fairly constant supply to the metropolis. While every province in India possesses lac, the supplies are mostly used up locally, except in the case of the Central Provinces, Bengal, Assam and Burma, where there are available for the foreign traffic large surplus stocks over local demand. Calcutta is the chief emporium of the trade and India might almost be spoken of as enjoying a monopoly in the world's supply.

The World's consumption of Lac.

9 *Prices of Lac.*—The Secretary to the Bengal Chamber of Commerce, in a letter dated 11th June 1896, very kindly communicated the following interesting particulars :—"The world's consumption of lac between 1876 and 1895 has been approximately per annum :—

Orange	50,000 cases.
Garnet	12,500 „
Button	12,500 „
TOTAL .	75,000 „

Increase.

"In recent years there has been a slight increase in the consumption.

"The average for the past ten years is somewhat higher than that given above Thus approximately :—

Orange	58,000 cases.
Garnet	13,500 „
Button	13,500 „
TOTAL .	85,000 „

Decline of trade in Lac-dye.

"A quarter of a century ago there was a large trade in lac-dye and the dye was more valuable than the shellac. Lac-dye is, however, to-day practically valueless having been superseded by Aniline-dyes which have flooded the market.

Price of Shellac.

10. "The following table will show the fluctuations in the price of shellac per maund during the last 20 years. The figures refer to

TRADE IN LAC.

Prices Per maund of shellac and lac dye.

Messrs. Angelo Bros. mark ◇AC◇ the price of which varies from R2 to R5 below that of a well-known standard mark TN; the table also shows the price per maund of lac-dye until it ceased to be an article of export from Calcutta:—

Year.	◇AC◇ Garnet, limits.			A. B. Lac-dye, limits.		
	R	*a.*	*R*	*R*	*a.*	*R*
1875	55	0	70	25	0	
1876	35	0		15	0	25
1877	25	0		25	0	30
1878	17	8				
1879	21	0	65			
1880	60	0	40	21	0	
1881	40	0	30	2	4	
1882	30	0		2	4	
1883	25	0	30	0	8	
1884	30	0	25	0	8	
1885	25	0	20	No longer made.		
1886	20	0				
1887	17	0				
1888	20	0				
1889	20	0	30			
1890	30	0	38			
1891	30	0	40			
1892	42	0				
1893	40	0	50			
1894	50	0	55			
1895	55	0	60			

During 1896 shellac fluctuated between R40 and R60 per maund."

Demand in excess of exports: rise in price with reduction of stock on the market

11. One of the largest shippers of Lac from Calcutta wrote in 1893 that:—"The annual foreign consumption is estimated approximately at 100,000 chests of two bazaar maunds each and the annual shipments from India fall somewhat below this. As a consequence, the stock in London and all over the world, has steadily decreased, and this decrease has been accompanied by a persistent rise both in rupee and sterling prices.

"The London stock and the London sterling price for the ordinary standard quality on the 31st December are shown by the following figures:—

	Stock.		Price per cwt.
1887	68,380	C	58*s.*
1888	69,502	C	56
1889	56,882	C	75
1890	45,555	C	72
1891	34,872	C	93
1892	27,512	C	95 6*d.*

C. 1491-1511.

"The stocks in London at the close of last month were 25,681 C, and the London price 107s. per cwt. Of late years there has been a great rise in rupee values, but, owing to the extent to which these have been affected by the exchange fluctuations, we exclude them from this review. TRADE IN LAC.

12. "According to a contention put forward at home, shellac supplies are not increased, as a consequence of rising prices, which is commonly the case with other commodities, and this view is based on the belief that it is not profitable to propagate the Lac insect as a special industry, and that the crop of lac is simply the collection made by natives from unprotected and uncultivated trees.

"We need scarcely point out the importance to this country of preserving and extending this trade, which at present seems endangered by the rise of prices to a prohibitive level."

The above brief abstract of the trade in this commodity has been given here chiefly from its historic value as an introduction to a more detailed study of the production and manufacture of the various substances obtained from Tachardia Lacca. Further particulars regarding trade will be found in the pages below devoted to provincial production.

CHAPTER II.

THE LAC INSECT.

13. Having in the foregoing remarks briefly indicated some of the more striking features of the growth of the present trade, it may be desirable to give briefly particulars regarding—1st, the Insect; 2nd, the Production and Supply of Lac; 3rd, the Manufacture of Lac and Lac-dye from the crude article; and 4th, the Industries in which lac is an important necessity (more especially Indian Art Industries). THE LAC INSECT.

As already stated, the Lac Insect belongs to the order Hemiptera and the Family Coccidæ, the Scale and Wax Insects. The majority of the members of that family are dangerous pests to crops and trees. They subsist upon vegetable sap which they suck up by means of a proboscis or tube which they insert into the succulent tissues of the host. In the adult state the females at least are fixed, that is, have no power of locomotion. Mr. E. E. Green, *Government Entomologist*, Ceylon, who is perhaps the greatest living authority on this family of insects, says that "There is scarcely a single cultivated Characteristics of its order.

TRADE IN LAC.

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1879 . .	21	0	65			
1880 . .	60	0	40	21	0	
1881 . .	40	0	30	2	4	
1882 . .	30	0		2	4	
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1884 . .	30	0	25	0	8	
1885 . .	25	0	20	No longer made.		
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C. 1491-1511.

THE INSECT.

twigs on which it was found were from **Ficus religiosa**, the Peepal tree and were contributed by Mr. E. H. Walsh, Collector of Monghyr. It thus very possibly follows that the differences in quality of the lac of different regions may thus have its origin entirely in the species reared. And what is even of more practical importance still, it may be found that with a careful study of the Indian forms certain of these may be less addicted to the destructive moth pest than others. But in these remarks I am to some extent of course only speculating though, it may be added, that I am justified in so doing from the fact that ignorance of the life-history of an insect and of the forms of that insect leaves a wide range of possibilities as affording the key to the explanation of widely different products.

Description of Larvæ.

15. *Description.*—Lac, as already stated, is a resinous incrustation found on the twigs of certain trees and is produced around the bodies of vast colonies of the lac insect (**Tachardia lacca**). When the larvæ escape from the mother they crawl about in search of a fresh sappy twig. They are then minute red or orange coloured insects, of an elliptical shape, obtuse anteriorly, attenuated posteriorly; about $\frac{1}{40}$th of an inch long; they are devoid of any recognisable separation between the head and the thorax; possess six legs, two antennæ and two small marginal eyes; and lastly have two very long hairs on the anal extremity that arise from the penultimate segment of the body. At this stage it is impossible to distinguish the sexes.

Swarming. *Conf. with p. 207.*

16 *Swarming Periods.*—They are generally seen to swarm at two and, according to some writers, three seasons a year, *viz.*, about the first week of July and again the first week of December or in some localities as late as January. At the periods named the twigs of trees infested with the lac insect will often be seen to assume a reddish colour, owing to the countless masses (lakhs) of minute larvæ that are moving all over them. The larvæ continue to emerge at intervals for about a month. This is a wise provision since had they all appeared at the same time they might have been destroyed by unfavourable climatic and other disturbances. The vast majority, however, die, either from inability to travel the necessary distance to find a fresh feeding ground, or from being incapable of puncturing the bark to obtain nourishment.

Emerge at intervals.

17. *Formation of the Resin.*—Those that become fixed, at once proceed, in the process of digestion, to transform the plant sap sucked up by the proboscis and to exude from their bodies the resinous

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THE INSECT.

matter with which they become ultimately incrusted. All the while structural changes are taking place and the larvæ are being gradually matured into the perfect insects. If at this stage a portion of the incrusted mass be broken through and examined it will be seen to be of a cellular structure, and that there are two shapes of cells, *viz.*, a large circular cell, and, secondly, a smaller ovoid cell. The former will, moreover, be found to be much more numerous than the latter and to contain the female insects.

Appearance of Males. Swarming of Males. *Conf. with p. 202.*

18 *Appearance of the Males.*—About $2\frac{1}{2}$ months after the periods of swarming, *e.g.*, about the middle of September for the first brood, and the middle of February to 1st March for the second, the male insects commence to escape from the ovoid cells already mentioned. At this stage they are about $\frac{1}{17}$th of an inch in size, and according to Dr. Carter have two pairs of eyes. The males of the first brood are wingless, but those of the second have one pair of long transparent wings. (Conf. with Roxburgh's observations, page 14, and Carter's, page 21.)

Reproduction

19. *Reproduction.*—Upon the circular body of the female there are three openings which become developed as encrustation proceeds into three filamentous tubes. One is the anal aperture, the others are breathing stomata. The positions of these three apertures are indicated by the presence of a tuft of white powdery or hair-like filaments around each opening. Impregnation takes place through the anal aperture and the male insect then dies. Shortly after changes take place within the female. A central sac or ovary becomes greatly enlarged and charged with a bright red fluid. The eggs then appear within it and each female bears, it has been estimated, as many as 1,000. As these near maturity the female dies. The larvæ are by some writers supposed to eat the red colouring matter and make their escape through the anal opening and ultimately through the completely ruptured body of the female. On this subject Mr. Green writes to me—"It would perhaps be more correct to say that the larvæ are the colouring matter. It is the juices of the parent insect that go to form the huge brood and when these have escaped little is left of the parent but a dried and shrivelled skin."

Formation of Eggs.

The cycle is again repeated; and it will be noted that the incrustation formed by each brood contains no life after the emergence of the larvæ or young insects.

C. 1491-1511.

THE INSECT. Practical Lessons.

20. *Practical Lessons.*—The practical lessons to be learned from this somewhat strange and complicated life-history may be briefly summarised:—

1st.—There are two broods, the swarming of larvæ taking place early in July and again early in December.

2nd.—It is commonly stated that the proper seasons to collect lac are, in May to June for the one, and October to November for the other crop, but it is believed these periods have been fixed with a view to preserve the dye as well as the lac.

3rd.—Up to the emergence of the larvæ the female insect is alive and is continuing the process of formation of lac. If the dye be of no consideration therefore, collection might be delayed until after the escape of the larvæ and the consequent death of the female. In the *Statistical Reporter* (*Vol. II, p. 406*) the statement occurs "Stick-lac gathered after the insect has emerged is known in Lohardugga district by the name of *phunki*. It yields scarcely any dye but is very good for working into shell-lac."

4th.—The seed-twigs intended for propagation should not be removed until immediately before the period of swarming. Should seed-twigs be cut off before maturity has been attained, the loss of the supply of sap in the twig would kill the mother insects and the brood be lost in consequence The failures that have attended the attempts to send seed-twigs from one part of India to another have been due mainly to the fact that the seed-twigs were cut too long before the swarming period or too near it. In the latter case the larvæ would escape during transmission and finding no fresh twigs upon which to become attached would of necessity perish.

Method of Propagation.

5th.—The larvæ are so minute that the seed-twigs must be carefully attached to the plants upon which propagation is contemplated. A string tied across the twig will often suffice to check the swarming and the larvæ may be seen in thousands to have died in the vain effort to pass underneath the string. The best way is to impinge the seed-twigs across the bifurcations of the smaller branches of the tree.

6th.—The larvæ are so minute that they are doubtless carried from tree to tree by wind, by birds and by insects. The production of a winged generation of males is doubtless to complete the migration to other trees, effected by wind, birds and insects. It has been sometimes contended that the lac insect does not injure the trees.

THE INSECT.

Apart from the improbability of that assertion, nature seems to provide for a migration and it appears, therefore, possible that the deterioration in quality often complained of, may be due to too long cultivation on the same trees. But in this connection I may add that the Collector of Monghyr recently sent me a few twigs of the peepal tree with lac incrustations on them accompanied with a statement that the older *peepal* trees of that district were all being killed by the lac. On page 192 reference has already been made to this instance and the statement made that instead of showing Tachardia lacca these twigs were found to possess a new species of Tachardia (*Conf. with Sir Jones' remark para. 25 (p. 198)* regarding the *peepal* trees being killed by lac.

The above brief account of the lac insect practically tells all that is known regarding it. It may be of interest to many persons however to give here some of the more valuable and interesting descriptions of the insect and the formation of lac from the pens of the earlier writers :—

OLD ACCOUNTS OF THE LAC INSECT. Roxburgh, 1807 A D

Extract from the Asiatic Researches, Vol. II., 1789, pages 361 to 364.

"On the Lacsha or Lac Insect.

By Mr. William Roxburgh."

21. "Some pieces of very fresh-looking lac adhering to small branches of Mimosa cinerea,* were brought me from the moun-tains on the 20th of last month. I kept them carefully, and to-day

excrescences were observed with a glass amongst the perforations, from which the minute insects issued, regularly two to each hole, and crowned with some very fine white hairs. When the hairs were rubbed off, two white spots appeared. The animals, when single, ran about pretty briskly; but in general they were so numerous as to be crowded over one another. The body is oblong, tapering most towards the tail, below plain, above convex, with a double, or flat margin: laterally on the back part of the thorax are two small tubercles, which may be the eyes. the body behind the thorax is crossed with twelve rings; legs six; feelers (antennæ) half the length

Description of Insect.

* Dichrostachys cinerea, *Wight and Arn.*

better described, with respect to appearance, than by saying it is like the transparent amber that beads are made of: the external covering of the cells may be about half a line thick, is remarkably strong and able to resist injuries; the partitions are much thinner; the cells are in general irregular squares, pentagons, and hexagons, about an eighth of an inch in diameter, and ¼ deep; they have no communication with each other: all these I opened during the time the animals were issuing contained in one-half a small bag filled with a thick red jelly-like liquor, replete with what I take to be eggs; these bags, or utriculi, adhere to the bottom of the cells, and have each two necks, which pass through perforations in the external coat of the cells, forming the fore-mentioned excrescences, and ending in some very fine hairs. The other half of the cells have a distinct opening, *and contain a white substance, like some few filaments of cotton rolled* together, and numbers of the insects themselves ready to make their exit. Several of the same insects I observed to have drawn up their legs, and to lie flat; they did not move on being touched, nor

OLD ACCOUNTS OF THE INSECT. Roxburgh.

it is a flattened point, about the middle of the breast, which the little animal projects, on being compressed

23. "*December 6.*—The male insects I have found to-day. A few of them are constantly running among the females most actively; as yet they are scarce more, I imagine, than one to 5,000 females, but twice their size. The head is obtuse; eyes black, very large,

Males winged. Number present

Conf. with pp. 194, 202.

six; wings membranaceous, four, longer than the body, fixed to the sides of the thorax, narrow at their insertions growing broader for two-thirds of their length, then rounded; the anterior pair is twice the size of the posterior; a strong fibre runs along their anterior margins, they lie flat, like the wings of a common fly, when it walks or rests; no hairs from the rump, it springs most actively to a considerable distance on being touched, mouth in the under part of the head; maxillæ transverse. To-day the female insects continue [illegible]

24. "[illegible]

move abc[illegible]

There ha[illegible]

Mimosa cinerea and corinda* put into the wide-mouthed bottle with them, they walk over them indifferently without showing any preference, nor inclination to work, nor copulate. I opened a cell whence I thought the winged flies had come, and found several, eight or ten, more in it, struggling to shake off their incumbrances.

* This is most probably a typographical error, as there does not appear to have ever been a species known as Mimosa corinda.—G. W.

OLD ACCOUNTS OF THE INSECT. Roxburgh.

they were in one of those utriculi mentioned on the 4th, which ends in two mouths, shut up with fine white hairs, but one of them was open for the exit of the flies, the other would no doubt have opened in due time this utriculus I found now perfectly dry, and divided into cells by exceeding thin partitions. I imagine, before any of the flies made their escape, it might have contained about twenty. In these minute cells with the living flies, or whence they had made their escape, were small dry dark coloured compressed grains, which may be the dried excrements of the flies."

"Note by President."

25. "The Hindus have six names for Lac; but they generally call it *Lacsha*, from the multitude of small insects, who, as they believe, discharge it from their stomachs, and at length destroy the tree on which they form their colonies A fine *Pippala* near Crishnanagar is now almost wholly destroyed by them."

It is curious that Sir William Jones should in the above passage have drawn attention to the fact that the lac insect was known to kill the *peepal* trees of Krishnagar. A recent correspondent has made the same observation regarding the *peepal* trees of Monghyr. (Conf. with paras. 20 and 66)

Passages taken from the Journal of the Agricultural and Horticultural Society of India, Vol. XI., Part II, July 1859 to December 1860, pages 37 to 45.

On the Natural History of the Lac-Insect (Coccus lacca).
By H. J. Carter, Esq., F.R.S.

Carter, 1859 A.D.

26. "Having had an opportunity of examining the lac-insect just previous to the evolution of its young, and of watching the latter from this period up to the time at which they become incarcerated in the resinous substance which they secrete around themselves, known in commerce by the name of 'lac,' and finding that a description of the changes which the insect undergoes still remains unpublished, so far as I am aware, while that which has been stated on the subject is more or less incorrect, I am not without hope that the following observations may prove both new and acceptable.

"Thus much is known that the substance called 'lac' consists of a resinous incrustation partly encircling or scattered over the small branches of several trees and shrubs of different kinds in India; that the incrustation is cellular, and that each cell indicates the position of one of the insects which secreted it; that the insect contains a red colouring matter called 'lac-dye,' which is also an article of commerce, and is allied to cochineal; and that, at a certain period of the year, vast numbers of young animals leave these cells and, spreading themselves over the neighbouring branches, fix themselves to the

CARTER'S ACCOUNT OF THE INSECTS.

bark, which they pierce with their beaks, and then begin to pour forth from their bodies the resinous substance above mentioned.

27. "On the 25th of June last (1860), my attention was drawn to the subject more particularly by a fresh branch of the Custard-apple tree (Anona squamosa), bearing portions of the lac, having been presented to me by my friend Major Burke. The branch was taken from a tree growing in the enclosure of the Bombay Mint, within a few yards of the sea, and in the midst of the smoke of steam engines, smelting furnaces, and the atmosphere of a crowded population;

olouring matter, both in

be less than that which

separated as well from

the sea as from all human habitations.

Female Insect.

or about the 1st of July; and by the middle of that month the whole branch had become covered with them; but for want of nourishment, as they became stationary, so they died without apparently secreting any of the resinous substance around them; and thus I was obliged to visit the Custard-apple tree itself for the purpose of examining the subsequent changes which the insect undergoes,—which changes, together with a description of the form and organology of the full-grown insect, so far as I have been able to ascertain them, will now be related.

Escape of Larvæ.

"The first feature that strikes the eye, on looking at the surface of the incrustation, when the insects which are within it are alive, is the presence of a kind of white powder, like that observed about the

here and there into little spots

n to be chiefly con-

ents, which radiate

are situated trian-

gularly with respect to each other, two being closer together than the

Anal and spiracular openings.

tracheæ.

29. "If we now examine the contents of the interior, which we *may easily obtain entire by dissolving off the lac in spirits of wine* (for, from their tenderness, they can hardly ever be extricated without

will be observed that

now almost as much

other,—consisting of a

ning, and presenting

id three papillary pro-

the elongated end, is

fixed to the bark; and the three latter, which project from the middle

Lac may be dissolved off, and insect exposed.

CARTER'S ACCOUNT OF THE INSECT.

of the obtuse end are respectively continuous with the three holes, in the lac above noticed. As with these holes, so with the three processes; one is much larger and longer than the other two, which

when in its insect form.

Dissolution after death.

30 "So far the spirit of wine assists; but when we come to the contents of the body, it is not only necessary to avoid using spirit of wine, from the disfiguration which it occasions by causing the tissues to contract, but also to extricate the body by fracturing the lac, and dissect its contents as quickly as possible, on account of the rapidity with which they pass into dissolution after death; this is probably the reason why this part of the history of the insect has remained unpublished up to the present time.

The Ovary.

"Directing our attention to the interior, after the rupture of the insect, which takes place more or less with that of the lac, we are at once struck with the voluminousness of the organ containing the red-colouring matter, which organ thus obscures everything else; and it is not before a quantity of it is removed by gentle edulcoration that we can (still under water, for the anatomy of this insect can be ... the other organs of the ... an alimentary canal, ... taining the red-colour- ... be the ovary. To each ... we will now give our attention.

Alimentary Canal.

31. "The alimentary canal commences with an attenuated, shapeless œsophagus, at the elongated end of the body, which is thus seen to be the oval extremity, and after passing upwards for about two-thirds of the length of the abdominal cavity, where it becomes enlarged and convoluted, turns back to make a single revolution, in the course of which it soon becomes diminished in calibre, and

bundles apparently without order, and send forth many of their extremities, through the two small, as well as through the large, anal apertures, to terminate on the surface of the lac in the way above mentioned.

Sexual organs.

32. "Lastly, we come to the ovary, which consists of a voluminous tree of tubes apparently branched dichotomously with each branch large and small, bearing long elliptical pouches, in each of which, again, is a correspondingly shaped ovum, the whole nearly filling ... ich opens (probably ... ovum, on the other ... ope filled with little

I am ignorant; but while they are both distinctly defined in the ovum when the insect is first opened under water, both soon burst by imbibition, and become lost to view by dispersion of their contents. Thus the red colouring matter exists originally in the form of distinct globules or in cells in the ovum.

33. "The further changes in the ovum, preparatory to the full d

o

a

Larva in July.

parts of the branch, and soon fixing themselves by inserting their beaks into the bark as before stated, commence secreting the lac or resinous substance, in which they soon become incarcerated. Myriads issue in this way, as may well be conceived when, at a guess, I should think, each insect contained a thousand; but by far the greater number die; for although the branches become quite red with them, it is only here and there that a few, scattered or in groups, live; the rest still remain attached to the bark, but dried up and dead, which may arise, perhaps, from not having been sufficiently developed, or not being strong enough at their delivery to pierce the bark for sustenance.

One thousand to each female.

34. "On leaving the parent, the young **Coccus** is of a minium red colour, about 1-40th of an inch long, elliptical, obtuse anteriorly, without any division between the head and body, possessing six legs, two antennæ, two small eyes, a marginal and lateral and two long hairs, growing from the penultimate segment of the abdomen; the body segmented regularly; the oral aperture ventral and placed at some distance from the anterior extremity, two tufts of white, powdery, hair-like filaments budding from the sides of the thorax respectively, in the place of wings, and a tuft of the same kind, bifurcated and curling outwards on each side, projecting from the anal orifice. Anal orifice surrounded by a row of short, strong hairs.

"At this period the insect is almost too small for examination organologically, but after it has crept off the incrustation and on to the bark of the branch, it soon becomes stationary, and enlarging, as the resinous secretion exudes from the surface of the body so as to surround all parts except the oral orifice and the three apertures from which the three white tufts issue, at the expiration of a month (that is, by the middle of August) it measures in length almost the 18th part of an inch.

Rapid Growth.

35. "If we now examine it minutely, it will be observed that the legs, antennæ, and the whole of the chitinous parts of the body have become almost undistinguishably incorporated with the resinous secretion, which, when dissolved from the insect by spirits of wine, leaves the body almost in a larval or caterpillar form, but without eyes or any other appendages, save the three white tufts or

Becomes Fixed.

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CARTER'S ACCOUNT OF THE INSECT.

hair-like filaments and the proboscis, which is now fully developed. The proboscis consists of a fleshy projection, situated at a little distance from the head, ventrally, presenting a depression in the centre, from which issue four long hairs or setæ, based internally upon as many pyramidal inflations, situated almost at right angles to each other, and supported by other horny elements, which also appear to belong to the machinery of the proboscis. These hairs together form the penetrating organ through which the juice of the tree is extracted; but whether they are hollow, and do this individually, or form a single tube by combination for this purpose, I have not been able to determine.

36 "On the other hand, the three apertures from which the white tufts proceed, and which are now seen to open through the incrustation are observed to be situated in the thorax and at the tail respectively—thus identifying the latter, which will present the circle of hairs round the anal orifice, with the large papilla or anal orifice of the full-grown insect, and the former or thoracic apertures with the two other papillæ, which appear to replace the wings. The white tufts projecting from all these we have already found to consist of the extremities of the tracheæ covered with a white powder.

"Thus we see that the increase of size which takes place in the female insect, from its locomotive form to its ultimate development in the fixed state, is chiefly effected by an enlargement and elongation of the body between the mouth, on the one hand, and the parts from which the three white tufts project, on the other, for the oral extremity simply becomes elongated, and the three other openings of the body remain as near together in the resinous incrustation, at the end as they were at the commencement.

'Of what the white powder on the tracheæ consists I am ignorant, further than that it does not dissolve in spirits of wine like the lac, which, on the other hand, appears to be a secretion from the skin generally analogous to the chitinous one which would be required under other circumstances."

Male Insect.

37. *Male Insect.*—"On the 8th of September I visited the Custard-apple tree again to see how the incrusted young were progressing; and, on close examination of the parts where they were most congregated observed, here and there, little red insects actively crawling over them, which insects appeared so like original young ones, that I thought they must be a few stragglers of a later evolution; but on inspecting them more particularly, they were observed to possess much larger antennæ; and therefore it was concluded that they were males, which afterwards proved to be the case. Several of them were collected for description, and a small portion of one of the branches, more or less covered by the incrusted young, brought away, to show how the secretion of the lac was progressing.

38. "The male is a little larger than the young ones at their exit from the parent; it has larger antennæ, which are hairy-plumose [illegible] two basal ones; [illegible] two long hair- [illegible] eding from the

CARTER'S ACCOUNT OF THE INSECT.

penultimate segment above; and a beak-like horny extension from the last segment, which is curved a little downwards and composed of two members, an upper and a lower one, both grooved, and forming together a cylindrical channel, through which the semen is conveyed into the female.

Production of males.

39. "Thus the changes which the larva undergoes during incarceration to produce the male, consists in an enlargement and alteration in form of the antennæ; in the differentiation of the head and the addition of two large eyes underneath it, which appear to be for the purpose of enabling the male, as he crawls over the lac covering the females, to find out the apertures in it that lead to the vulvæ; in the addition of the male organ, and in the replacing of the two hairs growing from the penultimate segment on either side of the tail by two delicate, white, twisted cords, composed of the attenuated extremities of the tracheæ. There are further differences between the sexes at this period, in the female having lost all traces of eyes, antennæ, and legs, while, no differentiation having taken place between the head and body, the female is reduced to a mere elliptical sac with but faint traces of the original segmentation. From the thorax, however, project the two tufts of white tracheæ which are absent in the male, and also a tuft from the anal extremity, the two hairs before alluded to having disappeared altogether; but the row of hairs round the anus, which are now absent in the male, still remain in the female, and appear to serve the purpose chiefly of

Characteristics.

the performance of his special function, the latter has become retrograde and permanently incarcerated for hers So unsparingly does Nature deal with her forms for the development of the new beings!

41. "*Impregnation.*—After having taken home the small portion of the branch above mentioned, which was covered more or less with the newly incrusted brood, on which there were no free males, I was astonished, on taking it up an hour or two afterwards, to observe that two had made their appearance, and were actively engaged in impregnating the females. This they do by drawing the organ before described downwards and a little forwards just over the hole in the lac which leads to the anal orifice of the female, and then inserting it; after which the male sits on the hole as it were, for a few moments, and then, withdrawing the penis, goes to another female, and so on till his office is fulfilled.

Males and Females on the Twigs.

42. "I now watched the process for some time; and having sufficiently satisfied myself of the fact as just stated, the two males were removed for microscopical examination, and the branch left as before without any. Next morning, to my astonishment, I again found two more males on it, actively engaged in performing their duty like the former ones; and then it struck me that they must come from some of the incrustations; so I examined the latter, and

CARTER'S ACCOUNT OF THE INSECT.

soon saw that there were two distinct kinds of incrustations on the bark,—one circular, slightly larger than the other, and, when *isolated* from the rest (which for the most part are agglomerated), presenting twelve notches or teeth symmetrically arranged round the base, six on each side, with the three holes above, and the white tufts projecting from them as before described; this, of course, was the female

43 "The other form of incrustation was narrower and elliptical like that of the young insect at evolution, but without serrated base, holes or white hair-like appendages. Finally, it was observed that the latter were frequently empty, and open at their unfixed and elevated end, while from others the tail of the male insect itself was projecting

Relative numbers. *Conf with* *p. 202*

"Thus the origin of the male and the process of impregnation as to time and act were easily determined; while it was also observed that in some parts there were almost, if not quite, as many male as female incrustations present, in others not so many.

Both sexes live on the twigs side by side for a time.

44. "On the evolution of the young, therefore, all at first would appear to attach themselves to the bark, and pierce it for nutriment —at least, all that live—preparatory to undergoing further general and generative development (for all are alike, apparently, when first hatched), and that then they respectively become changed for the fulfilment of their ultimate functions, the males for the impregnating the females, and the females for secreting the lac and developing the new brood; but the latter, as before shown, does not appear until the month of July of the following year Thus we see that the young Coccus as we have termed it merits rather the term of 'larva' (from the metamorphosis which it subsequently undergoes to pass into the matured forms of male and female respectively) than that of 'young insect'.

Lac not an exudation from the tree

45 "Again, all begin to secrete from their bodies the resinous substance even before they have fixed themselves to the bark; for those had it which are hatched from the lac on the branch that was first presented to me, after the latter was dry and dead; so that no doubt can exist of the lac being produced by the insect itself, and that it is not a mere exudation from the tree which follows the *insertion of its proboscis into the bark, as has been stated.*

"But while those which are to become males are entirely, though but temporarily, shut in by the lac which they subsequently elaborate from the juices of the tree on which they may be located, those which are to become females preserve throughout, the three apertures before mentioned, from which project the white tufts of tracheæ.

White tufts increased

46 "These tufts, which previous to impregnation consisted of but a few filaments from each aperture, and thus in no way impeded the functions of the male, had so increased immediately after impregnation (that is, by the 20th of September), that every part of the branch covered with the new lac was rendered white by it; and although there were still a few females which were not enveloped by it (and probably, therefore, were not impregnated) yet for the

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most part they were thickly covered by this cottony substance; and the few remaining males that were present were so inextricably entangled in it, and so prevented from coming into contact with the females by it, that, together with the presence of dead ones also entangled in the mass, it may be inferred that this rapid evolution of the cotton-like substance at once indicates the death-season of the males, and that impregnation has been fully performed. CARTER'S ACCOUNT OF THE INSECT.

47. "One other observation I would add, which is more practical than scientific, *viz.*, that, to obtain as much resin and as much colouring matter as possible, the gathering of lac should take place towards the end of May or the beginning of June, just before the evolution of the young, which, as will have been seen above, carry away with them the greater part of the colouring matter. In Ure's 'Dictionary of Arts and Manufactures', which contains by far the best, and least incorrect, account of this insect that I have met with, it is stated that the evolution of the young takes place in 'November or December,' and afterwards, in 'October or November,' while the lac is gathered twice a year, in 'March and October' It is also stated in the same article that the male insect has 'four wings,'* and that there is 'one to every 5,000 females,* while we are not a little surprised to see, in P. Gervais and van Beneden's 'Zoologie Medicale' (1859), p 374, that lac 'exudes from certain trees through the punctures which have been made by the females' Collecting Season: May June. Relative numbers of Males and Females.

48. "It was this and sundry other statements, together with seeing that the insect could be examined successfully only in the country where it lives, which induced me to avail myself of the opportunities presented to me of obtaining as much of its history as I could, for publication.

49. "On the 25th of *June* I received the branch of the Custard-apple tree with the living matured lac-insect on it in its incrustation. About the 5th of *July*, the young or larvæ, about $\frac{1}{40}$ th of an inch long, began to issue. On the 14th of *August* all were fixed to, and progressively enlarging, in incrustation, on the Custard-apple tree. On the 8th of *September* the males were leaving their incrustations and impregnating the females each sex being now about $\frac{1}{17}$ inch long; and on the 20th of *September* the females were almost all concealed under an exuberant evolution of the white cottony substance (which we now know to be the attenuated extremities of the tracheæ covered with a white powder), with a single male insect here and there alive and many dead ones, entangled in it."

Bombay, October 11, 1860.

ENEMIES AND PESTS OF THE LAC INSECT.

50. Very little of a definite kind is known regarding this subject. One of the most serious enemies, if one might say so, is the Native ENEMIES OF THE LAC INSECT.

* A statement originally made by Roxburgh, see page 197.

CARTER'S ACCOUNT OF THE INSECT.

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C. 1491-1511.

INSECT: Its Diseases and Pests.

cultivator himself. He is reckless and ruthless and through the greed of immediate gain very often materially interferes with the future supplies and at the same time only too frequently injures the host plant. Thefts are by no means infrequent and since lac is essentially a forest product great difficulty exists in guarding against such depredations. Hail also does considerable damage and unseasonal heavy rain often washes away countless colonies of larvæ. Forest fires are also exceedingly destructive to lac. Birds and monkeys are said to be enemies of a more or less serious nature and ants swarm on the lac trees in order to lick up the sweet excrement of the insects. By some writers ants are viewed as by no means harmless visitants In the Indian Museum Notes (*Vol. IV., page 77*) mention is made of the destruction of lac by ants. The treatment recommended, *viz.*, to paint a ring of tar around the trees so as to prevent the ants ascending the stem, was found to kill the trees. It was next recommended to place dry sand on the ground around the stems of the trees with a view to prevent the ants getting at them.

Heavy Rain. *Conf. with pp. 46, 58.*

Destruction by Ants. *Conf below para. 52.*

Black Fungus not a parasite.

51. A black fungus in a like manner grows on the excrement of the lac insect and is often mistaken for a pest. It is, however, quite harmless, though it gives the trees on which lac is found an unsightly appearance There are several species of parasitic fungi, which are found on scale insects allied to the lac, but so far as is known none of these have as yet assumed the condition of being blights on **Tachardia lacca.**

52. Mr. J. McKee who wrote in 1875 an exceedingly interesting report on the Lac industry of the Central Provinces (see below paragraph 149) makes the following observations regarding the pests found on lac:—

How Ants are harmful

[illegible]

appear to hurt the insects beyond biting off the ends of the white filaments, and thus bringing many an occupant of the cells to a premature end by cutting off the supplies of breathing air which the filaments serve to convey through the holes in the lac Where ants are seen about the lac it never appears healthy, and many cells are found with the insects dead inside them The lac whilst on the tree is also attacked by the larva of a moth, which appears to be a species of **Galleria** belonging to the ninth section of the **Nocturnæ**

Moths injurious

named Tineites by Latreille, one of which is famous for eating into the honey-comb of bees, living on their larvæ and destroying their wax. Our insect eats the juicy females of the Coccus and bores through the lac cells; it is found both in the field and the store room. A second species was also detected which appears to belong to the genus Tinea.' The ravages of these insects destroy the colouring matter contained in the females, and also all hopes of a brood of young from the cells visited by them. At present there seems to be no way of protecting the lac from their depredations. The ants, however, may be circumvented, in two ways, either by surrounding the trees with wood ashes, or something sufficiently attractive to draw their attention away from the incrustations." INSECT: Its Diseases and Pests.

53 In December 1898 Mr. F. F. Mackenzie, Manager of the Rajpur Estate, Cachar, sent a sample of lac attacked by the caterpillar of a small white or grey moth. He asked for any method of destroying that insect which he said was doing serious injury. He remarked "these moths appear and lay their eggs in the immature lac on the trees and the larvæ on hatching out burrow through the cells and eat the red substance of the lac insects' bodies" "The moths," he added, "appear at all times of the year, evidently going through a number of 'cycles' like silk moths." The matter was referred to Mr. E. E. Green, Government Entomologist, Ceylon, but unfortunately he could not identify the insect since the sample contained "two larvæ and a small portion of a deformed moth." Mr. Green remarked, however, that the larvæ had the appearance of a Pyralid, but the small portion of the moth looked more like a Noctuid of the genus Eublemma—several of which feed upon Coccidæ. He added "I have reared E. amabilis from a species of lac insect in Ceylon and also several Tineidæ." Moths attacking lac.

54. As to any method to get rid of the pest Mr Green continued: "Without thoroughly knowing the local conditions, and in the absence of exact knowledge of the pest itself, it is extremely difficult to offer any recommendations I can only suggest one or two lines of experiment. Your correspondent suggests the lighting of fires to attract the moths from the trees. A surer and probably more economical method of attracting them by light would be to set up in the trees small cocoanut-oil lamps each placed in the centre of a vessel containing kerosine and water. The light could be sheltered from the rain by a small piece of wood or tin fastened on to the tree above. The moths would be singed in the flame and fall into *the kerosine and water surrounding the lamp.* Means of destroying such moths.

C. 1491-1511.

THE LAC INSECT.

55. "During the monsoon, however, the wind would possibly extinguish the lights. At such times the use of small moth traps might be tried. A wooden box (such as a small tea chest) might be fitted on its open side with two sheets of glass sloping inwards, leaving a gap of about 1 inch, thus forming a funnel-like entrance to the box. A small lamp could then be placed inside the box, and behind it a sheet of tin to act as a reflector. Moths attracted by the light would find their way in through the gap between the two sheets of glass, but on account of the opposite slope of the glass they would be unable to find their way out again and in the morning could be easily killed. Such little traps could be placed at intervals through the plantation.

56. "Such means, however, though they might reduce the pest to a certain extent, would only give very partial relief. The insects could never be eradicated in this manner, and it is very difficult to conceive of any really radical treatment. The pest and its prey being both insects, it would be difficult to find any insecticide that would act on the one without the other.

57." I presume that the area of cultivation is too extensive, and the crop of insufficient value, to admit of the protection of the lac insects by means of muslin (or net) sleeves. It might be worthwhile to try binding soft grass loosely round some of the lac incrusted branches to see if it would keep out the moth. The experiment should be tried on the very young lac before the appearance of the caterpillar."

Eublemma amabilis one of the destructive moths

58. In the *Indian Forester, Vol XXVII., January 1901, pages 24-25*, a most interesting paper on Eublemma amabilis, one of the pests of lac, was published by Mr. D. G. Witt of the Forest Department. The specimens of lac from which this pest was subsequently reared had been collected in Damoh Division of the Central Provinces where they were found growing on Zizyphus xylopyrus. "I first noticed the attacks on the 26th September and collected some of the larvæ. The larva is white and unmarked, the head only being dark. It appears to feed upon the soft bodies of the lac [illegible] resinous coat- [illegible] with the outer air [illegible] reddish excreta. Whether the tube is formed just previous to pupation, as a tunnel of escape for the perfect insect, I am not aware. Mr. G. C. Dudgeon, F.E.S. of Palampur, Punjab, to whom I am indebted for the naming of the insect and to whom I sent specimens of the larvæ, perfect insect and a specimen branch of the lac incrustation attacked by the larvæ of Eublemma amabilis, is of opinion that these silk tubes are made

ENEMIES OF THE LAC INSECT.

as a tunnel of escape, as the tubes are all of the same size and therefore presumably formed by larvæ in the same stage of development; and portions of the pupa shell were found inside the resinous coating just beneath these tubes On the other hand, I did not notice that these tubes were ruptured by the emergence of the perfect insect.

59. "Six imagos of the larvæ which I collected early in November 1899, emerged between January 12th and 20th, 1900 Three more between January 22nd and 27th and two more on February 17th It would appear therefore that one generation of the insect lasts about seven months, as the lac incrustation only begins to form in August."

60 "Mr. Dudgeon informs me that so far E. amabilis has only been recorded from Ceylon and Sikkim and now Damoh It would appear therefore to have a wide distribution and it would be interesting to know whether it affects for instance the lac in Bengal and Assam. I also understand that it adds only the second species to the genus Eublemma now known to feed on a species of Coccidæ, ... *...imson.* It would ... estigation in this ... other members ... ore interesting points requiring ... amabilis I may mention the ... bring forth some information from other quarters:—

"1 Does E. amabilis attack both crops of lac? So far I have only found it on the winter crop.

"2. Does it attack lac on trees other than Zizyphus xylopyrus?

"3. How many generations of the insect are there a year? (There must surely be more than one because the interval between January when the imagos emerged, and August when the winter crop on which I found the larvæ commences to form, is unaccounted for)

"4. The eggs, their form, colour, etc, and where are they deposited?

61. "Other points will suggest themselves to those interested in the matter, and I therefore need not add to the above.

"Owing to my being transferred to another district, I have been unable to continue my investigations on this interesting insect, but the above noted may lead to some one filling up the gaps I have mentioned."

62. A number of very admirable samples of stick lac having been presented in 1900 to the Indian Museum by Messrs. Carapiet & Co. of Mirzapore, these were arranged in a special show-case. Shortly after it was observed that two species of insects were escaping from the lac in addition to the males of the lac itself. One of these was a

ENEMIES AND PESTS.

small yellow-brown moth which is as yet unidentified. This would appear to be the most destructive of all the pests of lac and to be very possibly the insect alluded to by the writers whose opinions have been briefly reviewed above. (*See paragraphs 52, et. seq.*) The second insect was also a species of moth but much smaller and of a very dark, almost black, colour. Unfortunately the material of this species was too imperfect to allow of determination. It may be added that the escape of the former from the incrustations of lac was carefully observed so that there can be no doubt that its larvæ feed on the lac. It may be further remarked that the moths continued to escape from the lac day by day over a period of at least two months and for a fortnight to three weeks after the appearance of the males of Tachardia lacca from the same sample.

63 These remarks regarding the pests of lac may, therefore, be usefully concluded by inviting attention to Mr. Ryan's interesting paper regarding the product in Sind (paragraph 196) where apparently it does not suffer from pests of any kind.

TREES FEEDING LAC.

TREES ON WHICH THE LAC INSECT IS REPORTED TO FEED.

64. The following may be given as a fairly complete list of all the trees and shrubs on which the Lac Insect has been reported to feed :—

1. Acacia arabica, *Willd.* (Leguminosæ). The *Babul* or *Kikar*. In Sind, Rajputana, and Guzerat yields large quantities of lac, is also said to do so in Berar and in the Punjab.
2. Acacia Catechu, *Willd.* (Leguminosæ). The *Khair*.
3. Albizzia Lebbek, *Benth.* (Leguminosæ). The *Sirin* of the Punjab and *Sirus* of Sind.
4. A lucida, *Benth* *Silkori*, Bengal
5. Aleurites moluccana, *Willd.* (Euphorbiaceæ). The *Akrot* of the plains, introduced from Malay, now almost wild, especially in South India. It is mentioned as bearing lac in the Punjab.
6. Anona squamosa, *Linn.* (Anonaceæ). The *Ata*, a tree introduced from the West Indies; specially mentioned as affording lac in the Punjab.

C. 1491-1511.

TREES WHICH FEED LAC.

7. **Butea frondosa**, *Roxb.* (Leguminosæ). The *Dhak* or *Palas* (Hind), *Khankar* (Raj.), *Pankbın* (Burmese). Throughout Bengal, Berar, the Central Provinces, Rajputana, portions of the North-Western Provinces, South India, and Burma.
8. **B. superba**, *Roxb.* A climber, scarcely distinguishable from the tree **B. frondosa**, except by its habit. Lac found on it in Chutia Nagpur, the Central Provinces and Berar.
9. **Cajanus indicus**, *Spreng.* (Leguminosæ). The *Arhur dal.* Northern Bengal and Assam.
10 **Carissa Carandas**, *Linn.* (Apocynaceæ), var. *spinarum* (sp., A DC). Yields lac in the Punjab.
11. **Celtis Roxburghii**, *Bedd.* (Urticaceæ). Punjab, Eastern Bengal, Central and South India
12. **Ceratonia Siliqua**, *Linn.* (Leguminosæ). The Carob Tree; now almost naturalised in the Punjab and South India
13. **Cordia Myxa**, *Linn.* (Boraginaceæ). The *Lasura* of the Punjab.
14. **Croton aromaticus**, *Linn.* (Euphorbiaceæ). Yields the medicinal lac of Ceylon.
15. **Dalbergia cultrata**, *Grah.* (Leguminosæ). The *Yindaik*, Burma.
16. **D. latifolia**, *Roxb.* The *Shisham* tree
17. **D. paniculata**, *Roxb.* The *Dhobeyne*, mentioned in connection with the Central Provinces also Berar.
18. **D. Oliveri**, *Brandis.* The *Tamalan* of Burma.
19. **Dichrostachys cinerea**, *W. & A.* (Leguminosæ). The *Virtuli*, a shrub of Central and South India.
20. **Dolichandrone Rheedii**, *Seem.* (Bignoniaceæ). A small tree of Burma and the Andamans Islands.
21. **Eriolæna Hookeriana**, *W. & A.* (Sterculiaceæ). The *Bules* of the Central Provinces.
22. **Erythrina indica**, *Linn.* (Leguminosæ). Specially referred to in connection with the Punjab.
23. **Feronia Elephantum**, *Correa.* (Rutaceæ). Is reported to yield lac in the Punjab.
24. **Ficus altissima**, *Blume.* (Urticaceæ). The *Bar* of Assam.

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TREES WHICH FEED LAC.

25. **Ficus bengalensis,** *Linn.* The Banyan tree, *Barh, Bar-ghat* of the Central Provinces; *Bargad* of Rajputana; is also mentioned as a lac tree in Berar, the Punjab and Sind.
26. **F. Carica,** *Linn.* The *Anjir* of the Punjab
27. **F. comosa,** *Roxb.* The *Juri pakari* of Assam.
28. **F. Cunia,** *Ham* The *Poro*, in Bengal and *Gular* in Punjab.
29. **F. elastica,** *Bl* The India-rubber Tree (the *Bar*).
30. **F. glomerata,** *Roxb.* The *Guler* of the Central Provinces, *Gular* of Rajputana.
31. **F. infectoria,** *Willd.* The *Pakar* or *Keol.* Is very frequently mentioned as affording lac.
32. **F. laccifera,** *Roxb* A native of Sylhet, the *Ruthal But.*
33. **F. palmata,** *Forsk.* The *Phagura* of Punjab.
34. **F. religiosa,** *Linn.* The *Aswat*, *Ahat* or *Pipal* Most provinces · but lac very different as a rule from that on other trees being larger in grain and much paler coloured.
35. **F. Rumphii,** *Blume* The *Jhuri* of Assam, an important lac yielding tree
36. **F. Tjakela,** *Burm.* The *Pakhar* of the Central Provinces and *Pilkhan* of the Punjab.
37. **Garuga pinnata,** *Roxb.* (Burseraceæ). The *Garuga* or *Kaikar*
38. **Grewia tiliæfolia,** *Vahl.* (Tiliaceæ). Berar.
39. **Kydia calycina,** *Roxb* (Malvaceæ). A small tree, the *Pola* or *Barranga* in Bengal and the Central Provinces.
40. **Lagerstrœmia parviflora,** *Hook. f.* (Lythraceæ). The *Bakli*, *Lendya* or *Sida.*
41. **Mangifera indica,** *Linn.* (Anacardiaceæ). The Mango, in its wild state, often yields lac.
42. **Nephelium Litchi,** *Camb* (Sapindaceæ). The Lichi.
43. **Ougeinia dalbergioides,** *Benth.* (Leguminosæ). The *Sandan* or *Tinsa*, mentioned in connection with the Central Provinces and Berar.
44. **Prosopis spicigera,** *Linn.* (Leguminosæ). The *Jhand* or *Kandi* of the arid zones of the Punjab, Sind and Guzerat.
45. **Pterocarpus Marsupium,** *Roxb* (Leguminosæ). The *Kino* or *Bija* tree, a native of Central and South India.
46. **Pithecolobium dulce,** *Benth.* (Leguminosæ). The *Dakhini babul*, a tree introduced from Mexico.

TREES WHICH FEED LAC.

47. **Schima crenata**, *Korth.* (Ternstrœmiaceæ). An evergreen tree of Burma

48 **Schleichera trijuga**, *Willd.* (Sapinadaceæ). The *Kusam* or *Kusamb.* This is the most important of all the lac trees It is a native of the sub-Himalaya, of Central and South India, and Burma.

49. **Shorea robusta**, *Gaertn.* (Dipterocarpaceæ). The *sal* tree. The ease with which this plant coppices, and its power of endurance and rapid growth make it one of the best trees for lac cultivation.

50. **S. Talura**, *Roxb* A native of Mysore where it is known as *Jalari;* sometimes called **Vatica laccifera.** *It is* the lac tree of Mysore.

51. **Tamarix gallica**, *Linn.* (Tamaricaceæ). The Tamarisk of Sind.

52. **Tectona grandis**, *Linn* (Verbenaceæ). The Teakwood or *Sagon*, a native of Central and South India and Burma.

53. **Terminalia tomentosa**, *W. & A.* (Combretaceæ). The *saj, piasal, asan.* Very abundant in Chutia Nagpur and the Central Provinces

54 **Xylia dolabriformis**, *Benth.* (Leguminosæ).

55. **Zizyphus Jujuba**, *Lam.* (Rhamnaceæ) The *Ber Bar*, or *Kul.* Although the lac yielded by this tree is inferior in quality, the ease with which it may be propagated makes it a good lac-yielding tree, suited especially to the Punjab, the North-Western Provinces, the Central Provinces, Berar, Central India, Rajputana and Sind *It is* also referred to in connection with Assam where it is known as the *Bogori.*

56. **Z. xylopyrus**, *Willd.* The *Kat-ber* or *Ghonti*—specially mentioned in connection with the Central Provinces and Berar.

It is perhaps undesirable to refer more specially in this place to the above plants, since in the sections of the present review devoted to the chief areas of production, the trees of greatest repute in these will have to receive special consideration. The present may be regarded as an alphabetical enumeration which may serve as a key to the positions where fuller details regarding the chief food plants of lac will be found.

INJURY TO THE TREES.

INJURY TO TREES.

65. Much difference of opinion prevails on the subject of the injury caused to the trees by the lac insect. It will be seen above (*paragraph 25*) that Sir William Jones alludes to the *Pipal* being frequently killed by the form of lac found on that tree. The following passage, from an interesting report by Mr. J. McKee, which has been placed under liberal quotation below (paragraph 149), deals with this subject:—

"It seems possible, owing to the great drain made on the sap of the young branches by the insects, that considerable damage will be found to result to the trees on which they are propagated, and that it will be necessary at some future time to fix a limit to the continuous cultivation of lac on the same tree, at any rate it will probably be found beneficial to both lac and tree, if a regular system of pruning be carried out to encourage the new formation of young twig or branch wood, and on the best methods of doing this, and on all other points in connection with the management of lac preserves we greatly hope that officers of the Department, who may have gained experience in this work in other countries, will convey all information available through the medium of *The Indian Forester*."

Passages taken from the Indian Forester, Volume XXII., pages 440-441, 1899.

NOTE ON THE INJURY DONE BY LAC TO TREES.

By* M. Ridley, Esq., *Superintendent of Horticultural Gardens, Lucknow, dated 6th June 1896.

66. "Regarding the statement commonly made, and as generally believed, that "if lac is not removed from trees it will in time destroy* the trees,' I have practically demonstrated and proved in the most conclusive way that the above theory is incorrect and entirely at variance with fact. When I first came here 23 years ago, the matter then came under my notice, many large trees in the Wingfield Park, Residency Grounds, and the station avenues, were badly infested with lac, and the plan then in vogue was to sell the lac to contractors, who in collecting it denuded the trees to a most objectionable extent. This led me to think of some way or means of keeping the trees clear of the pest. A Forest Officer informed me that this could be done by lopping off all the leading branches and afterwards stripping the branches and stems of all leaves and twigs,

* *Conf.* with Sir William Jones' statement on page 198 above.

INJURY TO TREES.

the object being to divest the trees of all the infected parts and to remove all trace of the lac insects and so prevent its breaking out on and spreading over the trees so treated again.

"I adopted this plan with one or two trees in the Wingfield Park, but found it ineffectual, as on the new branches and shoots which were developed, lac again appeared as badly as before. This plan proved an entire failure to protect or keep trees clear of lac

"I then decided to stop lac collecting on a few trees to test and prove the theory about its destroying the trees. The result of this experiment was that after a time the lac all disappeared and the trees in a short period recovered from the effects of the lac and became perfectly clear and healthy again. This is absolute fact, and I can show numerous large *peepul* and *pakar* trees, which at one time were so infected with lac as to be most unsightly objects now entirely free from the pest, and the trees healthy and vigorous.

67. "On the representation I made to Mr. Boys, when Deputy Commissioner here, he passed an order prohibiting the sale of lac from trees in the station, and since then I believe no lac has been collected from trees in avenues and groves of Lucknow; certainly none has been collected from any of the gardens and other public grounds in my charge, and there has been no loss of trees in consequence.

68. "For some years there has not been much lac on trees in Lucknow, at least on those in my immediate observation; but whether this decrease of lac pest is due to collecting being prohibited or to the seasons not favouring its spread, I am not prepared to pronounce an opinion, but the fact remains that it has been much less in evidence for the past five or six years than it was for many preceding years

"I have often been told that the lac gatherers inoculate trees to spread and propagate lac The results here rather favour that statement. Prohibition may have shown them that they gain nothing by spreading it, and this may have led them to cease inoculating trees, but on this point conclusive and certain evidence is not forthcoming

69. "I most decidedly do consider that trees are injured by the way lac is generally collected, owing to the removal of such a large portion of the young twiggy growth of the trees

"Near, and in towns, the object of this free removal of twigs is two-fold: one to obtain as much lac as possible, the other to make money by selling the twigs for firewood. If proper and efficient supervision could be provided, lac might be removed to some extent by collecting dead twigs and a small proportion of the finer ones. The trees would not suffer to any appreciable degree if collecting was done in this way; but as the necessary supervision to ensure this is not available, prohibition is, in my opinion, the only safe method to follow.

"The theory mentioned at the beginning of this note comes no doubt from persons interested in lac, and is a purely selfish one

"Others have accepted it from want of evidence to combat it, and so it has come to be generally accepted as fact. For this reason

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INJURY TO TREES.

it would probably be useful to circulate the facts and experience given in this note"

70. It may be useful to conclude these observations regarding the injury done to the trees by the lac insect by inviting attention to Mr. Coldstream's remarks on lac production in the Punjab (paragraph 189) Mr. Ryan's observations regarding the lac-yielding trees of Sind (paragraph 196) may also be read in connection with the supposed injury to the trees

CHAPTER III.

THE SUPPLY OF LAC, NATURAL PRODUCTION AND CULTIVATION.

DISTRIBUTION IN INDIA.

I have already indicated certain features of this subject. Lac is met with practically throughout the warm tropical areas of the whole of India, but most abundantly in the Central Provinces, Bengal, Assam and Burma.

71. *Relation to Environment.*—No satisfactory attempt has as yet been made to systematically investigate the relations of this insect to its environment And yet there are indications in the scattered literature of the subject of many highly interesting discoveries that await the investigator We have given us, for example, an extensive series of plants on which it may be found and even artificially reared. Of these we are told one tree yields in a certain locality the finest lac and in another only an inferior quality, or perhaps is never seen to bear the incrustations of this insect at all. In Sind and Guzerat, for example, the *babul* tree (Acacia arabica) may be said to be that on which it is met with most abundantly. In Bengal where both the *babul* tree and the lac insect are plentiful it is extremely rare to find lac on that tree. But is the *babul*-feeding lac-insect of Sind the same species as the *palas*-feeding insect of Bengal and the Central Provinces? Futile experiments have been made to convey the insect from Chutia Nagpur to Darjeeling while it seems probable success might have been secured had the seed been drawn from the moist warm temperate tracts of the Khasia and Garo Hills.

The same tree does not bear lac throughout India

This may be due to there being more than one species of Lac-insect.

It is repeatedly stated that in the warm dry tracts the lac-insect is subject to none of the pests that beset the industry in the moister areas. So again, we read of lac appearing sporadically on the trees of certain limited areas and after a time gradually disappearing.

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RELATION TO ENVIRONMENT.

72. I mention these examples, however, as but indicative of the extent of our ignorance Few parasitic insects are wholly indifferent to the climatic conditions under which they live or to the nature of the food plants upon which they subsist. In the absence, therefore, of direct evidence to the contrary we are almost compelled from such considerations to infer that there may be several widely different species or, if not species, at least races of this insect. That these have been so acclimatised or adapted to their environments that they cannot be arbitrarily translated from one end of this vast empire to the other or forced suddenly to feed upon plants they have never before (under certain climatic conditions at least) chosen to subsist on It is feared that in the present imperfect knowledge the wildest possible speculations have been indulged in and are likely to be repeated by persons who have advocated the establishment of an industry in Lac Cultivation That the insect should be and is, regularly and successfully grown in several isolated localities all over India, goes without saying That it is semi-domesticated over a still larger area is a well-known fact But the mistakes that have been made in the effort to extend production have not alone proceeded from over-sanguine financial expectations Failure has in many cases directly followed on ignorant misconceptions of the habits of the insect. It may, therefore, serve a useful purpose if I review here very briefly some of the facts that have been brought to light on the subject of cultivation or production

Special cultivation.

73. I shall endeavour, as far as possible, in the remarks that follow, to bring the information available under the names of the provinces concerned. Where quotations from authors are thought desirable these at the same time shall be given in historic sequence I would, however, add that it may not be always possible or even desirable to avoid repetitions of the same particulars where the object may be to exhibit the extent of local knowledge or the particulars of trade.

Bengal.

74. One of the earliest writers on the Lac trade of Bengal was Dr. Kerr. He published in 1781 an account of the production of lac on the *pipal*, the banian and the *palas*. He makes no mention, however, of any methods of cultivation or propagation. "The lac," he says, "is principally found upon the uncultivated mountains on both sides of the Ganges The only trouble in procuring it is in

Production and Cultivation. Earliest Author Dr. Kerr in 1781.

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breaking down the branches, and carrying the sticks to market. The present price in Dacca is about 12 shillings the cwt., and it is brought from the distant country of Assam."

75. A good deal has been written recently about Cajanus indicus (the *arhar dal*) as a plant upon which lac is reared in Assam. This is by no means a new idea, as will be seen from the following passage:—

Asiatic Journal, 1825, page 50.—Rearing of the Lac Insect. Written in 1809.

Buchanan-Hamilton's account. 1809 A.D.

[*Being an extract from a Statistical Account of the Rangpur District by* Dr. F. Buchanan (*afterwards known as* Buchanan-Hamilton)].

76. "The rearing of the Lac insect is confined entirely to the east corner of the district, but it extends from thence all through Assam, and probably might be carried on in every high part of the district, or of Bengal, for the animal thrives on many common plants. In my account of Mysore I have given a description of the manner in which it was reared on the tree called "jala" which I suppose is a specimen of sal or Shorea. In this district it is reared on the following trees:—

Pakur	Ficus infectoria.
Dhop	Varinga latifolia.*
Bot	Ficus religiosa.
Mejkuri	Morus Macassanensis.†
Mendu Kolai	Cajanus indicus.

"The first and last are the plants most commonly employed.

77. "The seeds of the "*mendu*" are sown in spring, generally in hedges round the garden. In the beginning of the cold season the insects are applied, by tying to each plant a small branch that contains them. In a year afterwards the small branches, then covered with the lac insect, are pruned, and in the year following this is repeated, after which the plant dies. In Bengal, where this plant is cultivated for the seed, it is generally an annual; but the pruning, which prevents it from running to seed, preserves its life for a longer period.

78. "The best lac is produced on the "pakur." Branches of this tree are planted in the rainy season, and in three years are of a size fit for receiving the insect, which is applied between the 15th of September and the 13th of November. In a year they have spread over all the small branches, and these are afterwards cut once or twice a year,

* This is no doubt a species of Ficus but the name *dhop* is not traceable to any species of the genus. It may have been Ficus Cunia.

† The plant referred to cannot for certain be identified: no species of Morus has been specially mentioned as a food-plant for lac.—*G. Watt.*

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for about 25 years. The trees are much stunted, but grow much larger than the "jala" on which the insect is reared in Mysore. A large tree will give two maunds ($84\frac{10}{36}$ sicca weight the seer), or about CULTIVATION IN BENGAL.

the farmer has about R8 for $173\frac{3}{4}$ lbs., which is sometimes produced by one tree, with very little trouble. The quantity raised is very inconsiderable."

79. I shall now endeavour to bring together a few of the more instructive passages from recent published works or the files of correspondence in the Office of Reporter on Economic Products that seem likely to prove of interest in exemplification of the produc tion or cultivation of lac in the province of Bengal. As a rule, however, I shall take the liberty to remove all passages in suchquotations that repeat facts of universal acceptance.

Passages taken from the Statistical Reporter, Vol. II, pages 406-407, November 1876.

Lac Manufacture in Chota Nagpur.

Lac in Chota Nagpur in 1876.

80. "From the resin is manufactured the shell-lac, and from the colouring matter the lac-dye of commerce. The entire secretion, while still adhering to the twig, is called stick-lac In order to obtain the largest quantity of both resin and colouring matter, the stick-lac should be gathered before the young come out. This occurs twice a year, in January and July, and the larvæ, as they emerge from the cells, carry away with them the greater part of the colouring matter. Stick-lac gathered after the insect has emerged is known in Lohardugga district by the name of *phunki*. It yields scarcely any dye, but is very good for working into shell-lac If the manufacture of lac-dye were discontinued, *phunki* would come largely into use, and the seasons for gathering would in that case begin immediately after the insect had swarmed Phunki Lac.

81. "The present seasons for collecting lac are from the middle of October to January, and from the middle of May to July. Thick jungles are the favourite haunts of the lac insect, which is found in large numbers in the forest-clad tracts of the Chota Nagpur division and the eastern districts of the Central Provinces. Ranchi, therefore, is a convenient centre both for the collection of stick-lac and the manufacture of the commercial products known as shell-lac and lac-dye; and a factory has for some years been in working close to the cantonment of Dorunda, under the name of the Ranchi Lac Company. Large supplies of stick-lac are drawn from the district of Lohardugga, and from Raipore and Sambalpore of the Central Provinces, at prices paid ranging, according to the proportion of

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CULTIVATION IN BENGAL. Two forms according to food plant.

refuse, from R10 to R20 per maund for lac gathered from the *kúsúm* and R10 to R15 for [illegible] Stick-lac from the *kúsúm* [illegible] which has the highest commercial value, while the raw material derived from the *pilás* yields a deeper dye, but a less valuable shell-lac than the former."

Extract from the Indian Forester, Vol. VII, 1882, pages 274-279.

Lac in the Sonthal Parganas in 1881.

Note on the Lac Industry in the Sonthal Parganas (1881), by O. F. Manson, Esq., *Deputy Collector.*

82. "When the lac insect (Coccus lacca), or, as the natives call it, *lakor lakh*, was first introduced into this district is not known, but there is a concurrence of opinion that the Paharias were the introducers, or, at any rate, the first cultivators of it, and the industry is known to have existed in some parts of the district for the last 40 or 50 years. The insect is supposed to have been introduced from Manbhoom, but this must be only a surmise, since the date of its introduction is not even approximately known. Lac is a cellular resinous incrustation, secreted by the insect round the branches of various trees, having a colour varying from a deep orange to a dark red according to the tree on which it is produced. It contains from 60 per cent to 70 per cent. of resinous lac, and 10 per cent. of a dark red colouring matter which is manufactured into lac-dye, the remaining 20 or 30 per cent being refuse.

Variation according to food-plant.

83. "Lac, as turned out by the manufacturers, is termed *shell-lac*, known to the trade by various names, such as *orange-leaf*, manufactured principally at Mirzapur in the North-West; *reddish orange*, *livery leaf* and *button*, manufactured at Ilam Bazar in Beerbhoom, and by the Ranchee Lac Company at Ranchi in Chota Nagpur; and *garnet lac*, manufactured in Calcutta.

"Lac, as sold by the growers, is termed *stick-lac;* and as there are no manufactories in this district, it is with this raw material that we have to do.

84. "Lac is cultivated in all sub-divisions of this district, but most extensively in tuppah Handwai, in the sudder or Dumka Sub-division and which is nearly in the centre of the district. In this tuppah the original, and still the principal, seat of the industry is taluk Kesri, which alone yields the Zamindar a revenue of R2,000 a year from the lease of groves of trees for the cultivation of lac. Besides taluk Kesri, lac cultivation has long been known in the villages of Kainjor in taluk Nadia, Jartal in taluk Singui, and Ashanhani in taluk Baji, all within the tuppah of Handwai.

85. "Haripur, the market town of Kesri, is still the chief business centre of this trade, although the industry has now spread to all parts of the sub-division. Its holding its own against the head-quarters town of Dumka is due, not only to its being the birth-place of the trade, and its still being in the centre of the chief producing area,

but because the exports being chiefly made to Mirzapur through Baidjanath Station on the Chord Line of the East Indian Railway, it is a more convenient centre for accumulating stocks, being only 43 miles from the station, whereas Dumka would be 48 The other markets in the sub-division for lac are Kumrabad, about 5 miles south-east of Dumka, Sarejahat 28 miles north-west, and Nunihat 17 miles west-north-west of Dumka

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"Although lac has been produced here for the last fifty years, it is only within the last nine or ten years that the industry has developed into an important item of our export trade

86. "I am not in a position to give accurate figures of the yield of the lac crops of past years; they might be compiled from the East Indian Railway records with some degree of accuracy, but the following statement of the principal traders' managers here, as reported by Mr. W. M. Smith, the Sub-Divisional Officer, shows sufficiently the extensive development that has taken place. He says:—'When I came here first, about eight or nine years ago, the annual crop was from 500 to 600 maunds. The last Bhadro crop (1880) yielded 16,000 maunds in the Dumka Sub-division, the Boishak crop (May 1881) about 6,000 to 7,000 maunds, and the present Bhadro crop (October 1881), which is not so good as last year's, is estimated at 10 000 maunds'. . . .

Expansion of Trade.

87. "The lac industry was no doubt stimulated in this district by the increasing demand that arose for the article in the London and United States markets in the years 1873, 1874 and 1875, the consumption of lac having been nearly doubled between 1870 and 1876. The price of lac was at its greatest height in 1873—74 since when it has declined again; . . . .
high prices having resulted
a demand for, the surplus s
year's demand. This was partly caused by the manufacturers adulterating the lac with common American rosin in order to keep pace with the demand. Before the production of lac increased, this adulteration is said to have been carried on until it reached from 50 to 70 per cent The fall in prices that took place after the increased demand had stimulated the production into overstocking the market is no doubt the cause of a falling-off in the cultivation reported from Godda and Pakour; but with a steady trade both production and consumption will increase, and already this year prices are again improving

Food Trees.

with the exception of Pakour, lac
the *palash* (Butea frondosa),
that it spreads itself to other trees
in the neighbourhood of the *palash* groves.

89. In Pakour it is said that the cultivation is principally carried on on the native plum tree or *bair* (Zizyphus Jujuba), Santali, *jamun*.

"In the neighbouring district of Beerbhoom it appears to be principally cultivated on the *pipal* (Ficus religiosa). Santali, *hesa*, a common enough tree here, but the lac is of inferior quality to that

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produced on the *palash*, which is a more plentiful tree than the *pipal* and one of the characteristic trees of the Sonthal Parganas It may be known to some as the 'flame tree' from its masses of bright reddish orange flowers.

"This tree appears to rise spontaneously from the ground, and is now being extensively preserved, so that the district is ready to meet almost any demand that could arise for the article.

"The best lac is, however, said to be that produced on the *kusum* (Schleichera trijuga), in Santali *baru*, on which it is, I believe, largely cultivated in Chota Nagpur This tree is also common enough here, but I understand that the insect-producing lac upon it is not the same that we have here. Our insect varies between red and yellow, whereas the *kusum* insect, or, as it is called, *naguli*, is solely red.

Races of Lac Insect.

"The *kusum* crop of lac appears also to be later than that from *palash* or *bair*, being from middle of May to July, and middle of October to January, whereas the *palash* and *bair* crop is from middle of March to May, and middle of August to October. The lac from *palash* is only very little inferior to the *kusum* lac, and at the same time it produces the deepest dye

90 "The seasons for setting and gathering the lac appear to be the same throughout the district.

Crops.

"There are two crops, the first in Cheyt and Bysakh, corresponding with middle of March to May, the second Bhadro to Assin, corresponding with middle of August to October. These crops, however, go by the name of Jeyth and Kartick, those being the months when the crop is in the local market

"Lac is cut before the larvæ swarm, the colouring matter being a portion of the female insect's body. Most of the colour would be lost if the insects were allowed to leave the cell before cutting; some portion of the lac would also be lost by their breaking through the covering of the cell.

"The crop of Cheyt-Bysakh yields the most and best lac, whereas the crop of Bhadro-Assin contains a greater proportion of colouring matter.

Season of Setting

91 "The manner of setting the insect for the next crop is simply to save a few well-covered twigs or a branch of the tree when cutting the crop, so that the new shoots thrown out by the tree being pruned down in the removal of the crop may be covered by the insect when it swarms, which for the Jeyth crop is in Kartick, and for the Kartick crop in Jeyth, corresponding with middle of October to November, and middle of May to June

"To set the insect in a new grove of trees a branch of healthy lac containing the larvæ is tied in each tree.

Lac without larvæ.

92. "After the larvæ have swarmed the branches that were left or tied on the trees are cut and the lac sold, this lac goes by the name of *Plunki*.

"The mode of preparing the crop for the market is primitive in the extreme, and must result in considerable loss of material, especially of the colouring matter. Where the incrustation has

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formed on thick wood, it is scraped off with the reaping-hook or some other rough instrument; where it has formed on thin wood, the parts wholly covered are left intact; where it is only partially covered the uncovered portions of wood are roughly cut off, so that a large amount of wood or stick is sold with the lac, hence no doubt its name of 'stick-lac.' The cultivation of lac, as before stated, was formerly confined to the Paharias, with whom the zemindars made their own agreement as to rent to be paid for the trees. At the recent Sonthali settlement the rent per tree was fixed at two pice, *that is, R3-2 per hundred; in many villages the groves of palash* now contain several hundreds of trees

93. "It may be said that all castes have now taken to producing lac of which the most numerous are Paharias, Sonthals, Bhuiyas, Khetoris, Goalas, Bauris, and a sub-division of the Kadar caste in Godda, called Leas. Several persons generally combine to work a lac garden, as watch has to be kept, lac thefts being not uncommon.

Profits of the Trade

"The growers generally sell to the village mahajun or shop-keepers, sometimes taking advances on the crop, sometimes exchanging the produce for salt, tobacco and such like; and sometimes being paid in cash. Although the crop is no doubt a very paying one, the growers generally do not seem to improve their condition by it. To this there are some notable exceptions amongst the better castes. The growers are said to have obtained only R3 to R4 per maund for lac some few years ago It then ran up suddenly to R27, R28, and even R30 near the railway; and then fell again to R12 and R13, and R8 and R9 per maund for last season's crop.

"The village shop-keepers who purchase from the grower, make a profit of from 10 to 20 per cent."

Extract from the Journal of the Agricultural and Horticultural Society of India, Volume VII., N.S., 1885, p 262

Hazaribagh District.

The Lac Insect and how I propagated it at Burhee, in the District of Hazaribagh, by Monsieur Claude Jean Dumaine.

94. "Some years back, there was a small forest of *parras* trees (B[illegible] firewood [illegible] them for pro- [illegible] with the said [illegible] ·ll set in, I had [illegible] so as not to [illegible] e *parras* forest and subdivided in pieces varying from 6 to 8 inches long, which

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CULTIVATION IN BENGAL.

twigs were immediately tied to the tender branches on the windward side of each tree The natural result was that when these twigs dried up, the insects took at once to the adjoining branches and subsequently covered the trees

"As a mere experiment, I tied some of these twigs on the opposite side of the tree, but this proved a failure, as no insect was found on it I naturally concluded that when the insects left the old twig, they were driven by the force of the wind to some adjoining arbor."

Passages taken from the Report of the Agriculture of the District of Lohardaga, by* Mr B C. Basu, *on the subject of Lac, pages 122-123, 1890.

Lohardaga District.

. 95 *Shell-lac* —There are seven lac factories in Chota Nagpur pro-
per—
one at
of Sor

SHELL LAC.

and collection of stick-lac are a source of considerable profit to the people of the five parganas and the jungly parganas to the south, west and south west of the sub-division. Almost every rayat of these parts has himself or hires a few *kúsúm* (Schleichera trijuga) and *palás* (Butea frondosa) trees on which he breeds the insect; some gather wild stick lac in the jungles, others again act as middlemen. Besides, some five or six hundred workmen are engaged in the manufacture of shell-lac The workmen of Bundu are one and all people from Sonamukhi, where they received their first training in the various processes of the manufacture.

96 "There are two different varieties of lac, *viz*, (1) *rangin* or *palisi*, grown on the *palas* and so called from its containing a large proportion of the lac dye Shell-lac made from *rangin* looks much darker than that from *kúsúmi*, which is translucent and of a beautiful golden yellow colour, and (2) *kúsúmi*, grown on the *kúsúm* above spoken of. Lac grown on *baer* (Zizyphus Jujuba) and *pipar* (Ficus religiosa), is classed with *kúsúmi*.

97. "The statistics of lac manufacture during the year 1887-88 are as follows:—

Number of factories	7
Number of persons employed (exclusive of the factory at Ranchi) . . .	123
Capital of the six factories	R7,400
Outturn of the „ . . .	Mds. 2,226
Its value	R50,641

"The large lac factory of Ranchi did not supply any figures.

"The industry is in its decadence owing to the great fall in price of shell-lac and the extinction of the manufacture of lac-dye, which has been completely replaced by aniline dyes. The dye washings are now thrown away."

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Passage from letter No. 22 C., dated the 24th April 1894, from* Mr. G. D. Chatterjee, *Forest Ranger in Charge, Palamau Division.

98. "The selling price of the seed lac here varies from 1¼ to 1½ seers per rupee fo [illegible]
yield of the seaso [illegible]
situated within 3 [illegible]
expenditure of 2 [illegible]
the seed lac at Daltongunj [illegible]

"The seeds of *palás* and *kúsúm* trees may be collected at Daltongunj at R2 per maund for the former species and 8 (eight) annas only for the latter The time for collecting *palás* seed is from the middle of May to the middle of June and that for the *kúsúm* is July and August

"If the above produce are required to carry up to Gya, the nearest Railway Station, it will further cost R6 (six) per maund when exported on a small scale by coolies and R2 (two) only when exported on a large scale by carts."

Passages from letter No. 110 C., dated the 21st August 1896, from* Babu Sreedhar Chuckerbutty, *Extra Assistant Conservator of Forests, Palamau Division.

99. "In 1895-96 the yield from 12 *kúsúm* trees in the Northern Range was 4 maunds 12 seers and from the seven in Southern Range 49 seers of lac.

"Among other interesting particulars the following may be mentioned :—

100. "***Explanation of terms used.***—*Morha* is the twig of the tree covered with lac. **Terms used in Palamau District.**

Dal is the lac which has become detached from the twig.

*Seed lac** is the morha from which the insect is crawling out and is tied into bundles and put on the branches of trees on which it is intended to propagate lac

Sita is the empty seed lac after the insect left it. It is lighter than the seed lac and of a yellow colour, while seed lac is pink from the colour of the insect crawling on it

101. "***Life-History.***—Rough life-history of the lac insect under cultivation :— **Life-History.**

"As the seed lac ripens an extremely minute pink larva emerges in myriads from the surface. It makes its appearance during the day, but goes back to the mother cell, which it shares with thousands of its kind during the night. At this stage the seed lac is cut from the original trees and bundles of it are tied all over a fresh tree which it

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* It will be seen that in trade "Seed-lac" has an entirely different meaning. *Conf. with p. 277.—G. Watt.*

CULTIVATION IN BENGAL

...on, as high up near the small ...nsect leaves the seed lac (which ... branches of the fresh trees and piercing the bark at some place sufficiently soft, fixes itself down and commences to secrete lac

Dangers to Lac.

102 *Dangers to Lac*—The lac insect at the time it leaves the protecting cover of the shell from which it emerges is most liable to injury as follows —

Fire

" *Fire*—A forest fire burning under and close to the tree on which the insect is crawling is likely to destroy a large number of insects, which being subjected to the intense heat and fumes of the burning, fall off the tree It is also subjected to some danger by the intense heat of the sun.

Birds and Monkeys.

" *Birds and Monkeys*—Birds also eat the insects to some extent, though this does not materially affect the crop since the insects are so numerous

' While the insect is actually growing and secreting lac, it is very moist and is at this stage liable to be damaged by monkeys, who eat the ' Morha ' and mischievously damage more than they eat.

Hailstorms.

Hailstorms—" These do most damage in breaking off numbers of twigs destined to bear lac and also by shaking off the insects on to the ground Hailstorms are most destructive to lac propagation, and wrought much damage to the crops in 1894-95.

Rain

" *Rain*—A severe downpour of rain, while the insect is still crawling, washes off a large number ...

Frost and Cold.

...ost does not ...cts returning

Theft

... at the same ..."

Assam.

CULTIVATION IN ASSAM.

103. At my request the Director of the Department of Land Records and Agriculture was good enough to cause a special enquiry to be instituted in the province regarding lac As a result Mr. B. C. Basu, the Assistant Director, published in the Provincial Bulletin No 6 full particulars Since the present review of information would be incomplete without the province of Assam, I shall reproduce here some of the more instructive paragraphs from Mr. Basu's paper, even although the paper itself may be readily procurable —

Production in Assam.

104 *Production of lac in Assam.*—Lac occurs in its natural state in various places in the forests of Assam and is reared more ...

CULTIVATION IN ASSAM.

the annual outturn of stick-lac in two mauzas (Rani and Chhayani) being [illegible] small quantity is reared [illegible] gion on the north bank. [illegible], however, obtained from Garos inhabiting the northern slopes of the Khasi Hills, who are said to annually bring in about 2,000 maunds of lac to the weekly markets at Palasbari and Chhaygaon and about 300 maunds to the market at Boko. A small quantity of lac, averaging about 400 maunds a year, is brought in by Bhutias to the annual cold-weather fairs at Darranga and Subankhata in the north of the district

Localisation of lac-cultivation and Superstition against it in parts of the Garo Hills.

105. In the Garo Hills, lac-rearing is chiefly confined to the north and north-eastern parts of the district, comprised in the northern range of the Garo Hills Forest Division. The people of the south and south-western parts are said to have a superstition against lac cultivation. The annual exports of crude lac from the northern range is estimated at 1,300 to 1,400 maunds In 1894, the Assistant Conservator of Forests, Garo Hills Division, estimated the annual production and export at 2,000 maunds, and reported a serious decline in the cultivation of lac, which he attributed partly to low prices and partly to the depopulation of the district through *kalá-dzár* and migration. Considering that the bulk of lac exported from the Brahmaputra Valley is the produce of the Kamrup and the Khasi and Jaintia Hills and the Garo Hills districts, and that the exports have during the past five years averaged over 16,000 maunds a year, the foregoing estimates of outturn of lac in those districts would seem to be much below the truth.

106. Very little lac is reared at the present time in any of the remaining districts of the province None is produced in the sadr subdivision of Goalpara, in the Goalpara subdivision, about [illegible]00 maunds are said to be collected annually. It is said that some twenty years ago, several thousands of Ficus trees were planted at the foot of the Garo Hills in the Goalpara subdivision for the sake of lac cultivation, but the plantation was abandoned owing to the country having been subsequently devastated by *kalá-azar*. In the North Cachar Hills, the annual yield is estimated at 100 maunds, and in the Sadr subdivision, Mr Mackenzie, of the Raipur estate, is reported to rear about 80 maunds annually. In Manipur, the annual collection is reported not to exceed 50 maunds in all, and the local produce is supplemented by imports from the Kubo Valley in Burma to meet the ordinary requirements of the people It is not known how much lac is produced annually in the districts of Darrang, Sibsagar and Lakhimpur. The Deputy Commissioner of Darrang reports that the lac-rearing industry in his district was ruined some years ago by a blight which largely destroyed the insect. It is still reared to a small extent by Cacharis in the north of the Mangaldai subdivision In Sibsagar, very little rearing is done now-a-days in the Jorhat and the sadr subdivisions The small amount of lac required locally is obtained from the jungles. Some rearing is, however, done in the Golaghat subdivision. Lac-rearing is said to be unknown in Nowgong and the Naga Hills.

CULTIVATION IN ASSAM.

Exports from Assam

107. *Exports of lac from Assam.*—The following statement exhibits the exports of lac from each valley and the total exports from the province for the last fourteen years for which trade statistics are available —

Year	Surma Valley	Brahmaputra Valley	Total
1	2	3	4
	Mds.	Mds.	Mds.
1885-86	177	29,916	30,093
1886-87	310	27,712	28,022
1887-88	132	27,450	27,582
1888-89	164	34,411	34,575
1889-90	240	15,190	15,430
1890-91	49	9,337	9,386
1891-92		14,753	14,753
1892-93	7	15,376	15,383
1893-94	130	6,017	6,147
1894-95	483	17,240	17,723
1895-96	183	15,732	15,915
1896-97	6,072	10,453	16,525
1897-98	29	24,840	24,869
1898-99	91	14,403	14,494

108 It will be seen that the Surma Valley contributes a very small proportion of the total exports. The trade reports furnish no explanation of the extraordinarily large and sudden increase in the exports of lac from the Surma Valley in 1896-97.

Upper Assam contributes an insignificant share of the total exports of lac from the Brahmaputra Valley. The bulk of the exports is shipped from the river ports in the Kamrup and Goalpara districts, and is the produce partly of these two districts and partly of the Garo and the Khasi and Jaintia Hills. A small portion of the exports is derived from Bhutan and Towang to the north of the Kamrup and Goalpara districts The annual imports have averaged 374 maunds from Bhutan and 13 maunds from Towang during the past five years.

Decline in Exports.

109 There has been a marked decline in the exports of lac since 1889-90 The annual export from the Brahmaputra Valley, which had amounted to 30,000 maunds, more or less, for some years before 1889-90, fell in that year to about 15,000 maunds, which it has seldom exceeded since It would seem that the causes which led to the decline of lac cultivation in the Garo Hills operated in a greater or less degree in every part of Lower Assam where lac is now reared.

With the exception of a few maunds of manufactured lac exported now and again, the entire quantity of lac exported from Assam is in the shape of stick or crude lac.

Method of rearing.

110 *Method of rearing lac.*—The method of propagating lac in Assam is practically the same as in Bengal. There are usually two

CULTIVATION IN ASSAM.

crops of lac in the year, one being collected in May and June and the other in October and November. In Sylhet, the first is called the *Aus* or early crop, and the second the *Aman* or late crop. The first crop is mainly used for seed purposes; the second is the chief crop and supplies the bulk of the exportable article. A few days after the harvest, pieces of stick-lac, containing living insects (*rahi-laha*), are tied on to the branches of the trees on which the next crop is to be grown. The usual plan is to place the stick-lac into small bamboo baskets and tie these on to the twigs of the trees. In a few days, the insects crawl out of the sticks, and spread over the young branches on which they at once begin to feed and secrete the resin. The secretion of lac is allowed to go on for about six months before it is gathered in. If sufficient lac has not been secreted, the insects are left undisturbed for another half-year. After the harvest, a fresh crop is immediately sown to be reaped six months later. It is said that a *Kathal bar* tree (Ficus altissima) can grow lac for three or four years in succession, after which it requires rest. Some trees have been known to produce lac for ten or twelve years without rest. A good-sized tree may yield from 30 seers to 2 maunds of stick-lac

Exhaustion of Food Tree.

111. The lac insect does not thrive on *Ficus* trees which are of vigorous growth and contain an abundance of gum, but thrives best on trees of moderate vigour. The lac crop is liable to several kinds of pests, among which the most injurious are a species of ant, and the caterpillars of a tiny moth, both of which feed on and destroy the insect. The depredations of ants can be prevented to a certain extent by keeping the trunks of the trees clean, and by attracting the ants with jaggery and then destroying them with fire Stormy weather at the time when the young insects are spreading over the tree may destroy them altogether

Fig Trees of Moderate Vigour give most Lac.

112. Some additional particulars of interest bearing on the cultivation of lac have been received from Mr. Dicks

113. Prior to receipt of the above special report the following particulars had been brought together in the files of correspondence and ledgers of the Office of Reporter on Economic Products. As these will be found to amplify in a few directions Mr. Basu's paper, they may be recorded here.

Passage from a letter received from the Assistant Conservator of Forests in the Garo Hills, Tura, 26th April 1894.

114. "Lac is produced in the north and north-east parts of the Garo Hills. The Garos who live in the south and south-west of these hills never have gone in for lac cultivation, and I have [illegible]

Missionary in [illegible]

They al[illegible]

spirits live in [illegible]

e Garos are a [illegible]

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superstitious people and many of the hill Garos very simple, it will be some time before they get rid of their scruples and fears.

Trees on which grown.

"The lac, which is cultivated in the north and north-east of the Garo Hills, is exported from Damra, Nibari, Jira, and Rongjuli *hats*, being brought to these markets by the cultivators who are for the most part Garos. The lac is cultivated on *Dal Arhar* and *Kapassuti*, 3 shrubs which the Garos plant scattered over their *jhum* cultivation. It is also found wild, but to no great extent, and is then met with on the *Pakri* (a species of **Ficus**) tree and on another tree called by the Garos *Boldaba*"

Former Prices.

years ago as much as R35 to R40 per maund was paid for lac in the local market, and that then the amounts exported were about ten times as much as now."

"I may add, though it is not in my district and may have already been reported to you by the Divisional Forest Officer, Goalpara, that in that district throughout the zemindari land at the foot of the Garo Hills there are many thousands of a **Ficus** tree which were planted 10, 15, or 20 years ago for the purpose of lac cultivation, but that now, owing to the country having been almost depopulated by the *Kalá ázár* disease no cultivation is going on"

Decline of Trade.

115. *Decline in Production.*—The Officiating Conservator of

tain in any numbers, the species of trees required for the cultivation of the lac insect. **Butea frondosa**, so far as I am aware, is the only wild tree in the Assam Forests, on which the insect could be reared, and this species is not found here growing gregariously."

Other Crops may have interfered with Lac Cultivation.

arried on exclusively by
. and it is believed that
228) is owing to the
rofitable to grow cotton
than to cultivate lac"

State Production Impracticable.

117. *State Production Impracticable.*—"Under any circumstances the industry in Assam is not one that could be fostered by the Forest Department, because, as above stated, it would be necessary

undertaking unprofitable or indeed impossible.

"The collection of a large revenue from this source in the Rewah State, was made practicable owing to three conditions, *viz.*:—

(1) Lac cultivation was made a State monopoly.

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(2) The trees required for yielding the best lac, namely, **Butea frondosa** and **Schleichera trijuga**, were very numerous in the local forests.

(3) Local wages are extremely low.

"None of these conditions obtain in Assam."

Dal a Popular Stock for Lac.

118. *Popularity of Dal as a Stock.*—In another communication, the Assistant Conservator of Forests, Garo Hills, reverts to the question of the popularity or otherwise of the crop. The following passages may be abstracted from his second report:—

"The cultivation is found exclusively in the north and north-east of the district and lac has never been cultivated in any other part of the hills. The people who have cultivated lac for some years like the cultivation; they say that on the whole it is more remunerative than cotton, and the work connected with it is very light, but they are not always successful, since some years almost their entire crop may be destroyed by ants, and I understand that there are other pests to which it is liable. The reasons advanced why many of the Garos have not cultivated lac are three-fold, as follows:—

Objections to lac cultivation put forward by Garos.

(1) *Superstition*: They say evil spirits dwell in the lac trees and shrubs and destroy their rice crops.

(2) *Injury to the Soil*: Their fear that their rice crops may be damaged since they say that (leaving aside evil spirits) the productive power of the soil is lessened when lac-producing shrubs are grown on it. They are unable to make two

the soil.

(3) *They are conservative*: They dislike making a change in the mode of getting their livelihood. Having been brought up to cultivate rice, or rice and cotton, and to look on lac as detrimental to the soil, they are too conservative to change."

emigrate through the failure of their crops.

Middlemen.

119. *Middlemen in the Lac Trade.*—The Assistant Conservator further remarks:—In lac cultivation as with any other crop in which the cultivator does not deal directly with the manufacturer, the question of middlemen is the great difficulty. Before the lac reaches Calcutta it

each of whom

Thus the culti-

next disposed

of to a Bengali trader at the markets of Jira, Nibari, and Damra.

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CULTIVATION IN ASSAM.

120. *Method of Propagation.*—The Director of Land Records and Agriculture, Assam, in a letter, dated Shillong, 7th March 1896, furnished the following particulars :—

Method of Propagation.

"With reference to your letter No. 1526-36, dated the 13th November 1895, asking for a note on the propagation of the lac insect on the *arhar* plant (Cajanus indicus), I have the honour to state as follows :—

Fresh seed-lac is put into a bamboo *shora*, a kind of conical cage (somewhat like a soda-water bottle in shape) formed of strips of bamboo connected with thread, and hung upon the *arhar* plant during the months of October and November and again in June. The cage is hung on the plant on the day the moon is in conjunction (*i.e.*, the *Amabasya tithi*). After expiry of a fortnight (a longer time is required during the winter), the lac insects begin to emerge from the lac in the cages and repair to the boughs of the plants. Like the worms of the *munga* or *pat* silk, these lac insects do not spread over the whole tree, they occupy the same bough to which the cages are hung, and in order to spread them all over the tree, some 8-10 cages must be fastened to the boughs. When the lac is ready the cultivator lops off the branches and collects it. Lac put on the plants in October and November, is gathered in June, and that put on in June is gathered in November. The summer crop is superior in quality and quantity to the winter one, which may perhaps be due to the damage done by the cold fogs of December and January

The proportion of seed to outturn is roughly 1 to 10.

The seed lac cannot be kept for more than 3 or 4 days before putting it on a new plant. The seed should not be exposed to the heat of fire or the sun or to the natural heat which is generated when the lac is heaped up : heat drives the insects out of the cells and so kills them.

Possible Changes of Food plant.

The lac reared on *arhar* plants can be put on to the other lac-rearing plants, such as (1) *Pakari* tree (Ficus cordifolia), (2) [illegible] India-rubber (Ficus elastica), [illegible] (Zizyphus Jujuba) and [illegible] le lac grown on *arhar* is the best.

121 *Practical Experience.*—The following appeared in the *Indian Agricultural Gazette* of 1887, but the writer cannot vouch for its accuracy though it seems to express personal knowledge :—

"The insect has no predilection for any particular shrub but experience has shown that the *arhar dal* shrub forms its most suitable habitat If sown and well watered in November, the young plant will be fit to plant out at the close of the following rains—the end of October, and each should then be a good stout sapling, averaging four feet in height. When planted in rows four feet by eight apart about 1,360 will go to the acre, and if well cultivated will be found [illegible] years from the date of [illegible] get your stock lac, but [illegible] the season, say, August. [illegible] the insect will be dried

Yield of lac from Cajanus indicus.

CULTIVATION IN ASSAM.

up in the cells and useless, about half a maund or forty pounds will be found sufficient for one acre, and though the cost for fresh material may amount to a rupee a seer (2lb), it is well worth the expense, for, once stocked, you are independent; the best method of conveying the lac to the factory is in baskets well lined with fresh plantain leaves." "If the insect has been left undisturbed and the shade properly attended to, three years from the commencement of operations and one from the introduction of the insect, each tree will yield an average of 8lb of lac, which, when freed from extraneous matters, such as twigs and leaves, and the dye washed out, will give 6lb per bush of clean seed lac, the present price of which, in the London market, at £40 per cwt., gives £144 per acre less charges, such as initial cost, up-keep, freight, etc., but if care is taken to leave sufficient nucleus on the branches this sum may be looked for annually without the expense of re-stocking."

122. A writer in *The Planter* (November 1898) takes a less hopeful view of this subject. He says "Cajanus (the *arhar dal*) yields well and attains sufficient size in 12 months, but it requires to be re-sown every two or three years, does not stand drought well, and any damage to its roots, by hoeing or otherwise, causes it to die."

North-West Provinces and Oudh.

CULTIVATION IN THE NORTH WEST PROVINCES AND OUDH.

123. One of the most interesting of the early writers on lac in these provinces may be said to have been Major Sleeman (*Trans. Agricultural and Horticultural Society, India, 1838, Volume VI., pages 47 to 51*). He was apparently the first writer who pointedly drew attention to the nature of cultivation of Lac as pursued with the trees Speaking of a visit to the Mirzapore Lac factory he says:—"I was much surprised to find that none of the gentlemen who superintended it were aware of the fact that lac is as much *cultivated** as any other raw material for manufactory, that is, that the insect is *put* upon the trees upon which it is found to thrive best; and that the quality, and consequently, price in the market, varies with the kind of the tree from which it is taken."

Major Sleeman's Account.

124. "The lac is gathered twice a year, the best crop in April from seed applied to the trees in October; the second, which is inferior, in November from seed applied in June." "The people have sufficient seed for the next crop upon the trees from which they gather; and they do not consider the produce to deteriorate from the same seed being left long upon the same tree." "I have asked the people whether the trees require a fallow or not, and have told me that they

Seasons of Collection.

* The italics are Major Sleeman's.

CULTIVATION IN ASSAM.

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Yield of lac from Cajanus indicus.

CULTIVATION IN THE NORTH-WEST PROVINCES AND OUDH.

it is with any other tree I know not. I do not think it is with any other tree that I have seen."

127. "I think that in the produce from the *Kusam* tree, the gum, or nidus, bears a larger proportion to the insects, or colouring matter, than in that from any other tree; another reason why the raw produce from this tree may not fetch a higher rate of price in the market, though each of the two component parts is admitted to be of a quality so much superior; because the gum is an article of much less value, compared with its weight, than the insects."

The opinion that *Kusam* yields a larger quantity and a finer quality of lac than is obtained from any other tree has been affirmed by many writers. The circumstance that lac taken from the *Kusam* may be propagated on most other trees but that the reverse is rarely, if ever, successful, has been mentioned on more than one occasion, but neither of these statements can be said to have been definitely explained nor even sufficiently verified.

In the North-West Provinces Gazetteer, Vol. XIV (1884) page 213, the following interesting passage occurs:—

Cultivation about Mirzapur.

[illegible]

the commercial prosperity of the city, as well as the architect of a considerable private fortune. The beginnings of the lac trade were aided by the then convenient situation of the city. The reputation made by the original manufactory, which, now owned by Messrs Jardine, Skinner & Co., still commands the highest prices in the market, has enabled the industry to hold its ground against subsequent rivals, in spite of their superior advantages of position. A short account of the material and the process of manufacture may be subjoined. Stick-lac is found upon the *kusam* (Schleichera trijuga), *palas* (Butea frondosa), *ber* (Zizyphus Jujuba), *pipal* (Ficus religiosa), *bargad* (Ficus bengalensis), *gular* (Ficus glomerata), *pakar* (Ficus infectoria), and many other trees. The best is that obtained from the *kusam*. This is a lig[illegible]
it the most [illegible]
from the *p*[illegible]
month (Ba[illegible]
colour thar[illegible]
clear and bright. These are almost the only varieties used by the

C. 1491-1511.

CULTIVATION IN THE NORTH-WEST PROVINCES AND OUDH.

European firms. The native factories, most of which turn out a very inferior article, utilize the produce of almost any tree on which the lac-insect is found. The best *nagali* comes from Sambalpur and Raipur, in the Central Provinces, and from the neighbourhood of Hazaribagh and Palamau, in Bengal. The latter places also give the best *baisakhi* and *katki*, but these varieties are to be found in many parts of the country.

The following letters from the files at my disposal may be given in this place as conveying useful particulars regarding the Lac production of the North-West Provinces and Oudh :—

Naini Tal

Copy of letter No. 611, dated the 21st February 1894, from the Conservator of Forests, Oudh Circle, North-West Provinces, Naini Tal, to the Inspector General of Forests.

129. "In reply to your demi-official Circular No 1, dated 3rd January 1894, the success of lac-cultivation appears to be dependent financially on the presence of suitable species in large numbers in a limited area In these Provinces the industry is worked by 'Manihars,' who take two crops a year from *Pipal, Dhak* and *Kusamb* ; the landowners who possess such trees are careful not to allow them to be felled and foster the industry as much as possible ; this is especially the case in the Kapurthalla Estates which comprise the Ekowna forests.

Bahraich Experiment.

"Many years ago when in charge of the Bahraich Forest Division, I obtained a supply of seed from Kapurthalla and sowed it throughout the Motipur Reserves, but the attempt to increase revenue from this source proved abortive owing to the isolated nature of the species above named.

"In no important area in this Circle can this difficulty be surmounted, but I will direct all Divisional Officers to endeavour to spread the artificial culture of lac by offering the most favourable terms to the castes engaged in the propagation of this insect."

Cultivation at Debra Dun.

Copy of letter No 96, dated the 10th May 1894, from the Conservator of Forests, School Circle, North-West Provinces and Oudh, Dehra Dun, to the Inspector General of Forests.

130. "I have the honour to submit my report in reply to your demi-official Circular No 1 of 3rd January 1894 That circular was sent to Divisional Officers in this Circle for report with the result that the Dun and Jaunsar Officers stated that they could obtain no information in their Divisions on the subject and could not find after enquiry that lac was grown. I think it likely that their statements are correct, both the Dun and Jaunsar being probably too cold for the insect.

CULTIVATION IN THE NORTH WEST PROVINCES AND OUDH.

The Divisional Officer of Saharanpur, Mr. A. P. Grenfell, who has interested himself considerably in the subject, has reported as follows:—

Saharanpur.

131. "Lac is collected in small quantities near Roorkee and Pathri where there are numerous *Dhak* trees scattered about the cultivated land. The lac is cultivated to a certain extent by the villagers, but is not cultivated systematically and on a large scale. The produce is taken to Saharanpur, Roorkee, Jawalapur and Deoband, and is there sold to workers in various industries."

"The lac sells from R8 to R10 per maund as it is collected from the tree; roughly cleaned lac unwashed but with sticks and stones picked out at R12 to R18 per maund. Seed-lac is not sold, as buyers take the uncleaned lac and clean it as they want it, but seed-lac of the same quality as the samples of lac prepared for analysis and sent to the Conservator of Forests with this office No. 299 of the 30th November 1893 would, according to Forest Ranger Pirbhu Lal, fetch R30 to R40 a maund in Roorkee and Jawalapur."

"The lac is used for making bangles and also (this probably refers to the dye) in tanning goat skins, also for varnishing turned wood articles, such as the legs of charpoys."

"There are no large dealers in lac and there is little trade beyond the borders of the district. If, however, the local supply is not equal to the demand, lac is imported from the eastwards and Riwari. Similarly, if there is a surplus of lac produced over local requirements it may be exported usually to the Panjab."

Extent of Trade.

132. "It is noteworthy that the price of seed-lac is high, but most probably, if a large amount of seed-lac were placed on the local market, it would not find purchasers and the price would be considerably lowered. Pirbhu Lal, Forest Ranger, Central Range, reports that Saharanpur uses 25 to 30 maunds of lac yearly and probably the total supply and consumption of lac in the district does not exceed 200 maunds yearly, excluding the external trade which is inconsiderable."

"There is much land in Pathri forests suitable for cultivating lac, but it would be undesirable, I think, to do so on a large scale unless the lac could be profitably exported from the district and sold at a large market, such as Mirzapur. It would not do to trust ... [illegible]

Valuation.

[illegible] ...ualities of ... [illegible]

... Sample No. 1 appears to be seed lac from fairly good new *Bysakee* stick-lac, but it has not been thoroughly washed, as there is

CULTIVATION IN THE NORTH WEST PROVINCES AND OUDH.

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CULTIVATION IN THE NORTH-WEST PROVINCES AND OUDH

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Valuations.

... l a considerable amount ... *Dhak* trees at Ranipur ... d cleaned by the Forest ...

valuations were for the three samples, respectively, R30, R28 and R25 per maund. Mr. Thurston also submitted them to Messrs. Jardine, Skinner & Co, who sent them to Mirzapore and from thence received a letter from Mr. C. E. K. Skinner, dated January 2, 1893, as follows:—

"Sample No. 1 appears to be seed lac from fairly good new *Bysakee* stick-lac, but it has not been thoroughly washed, as there is

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Bysakee and Katkee Lac

"Nos. 2 and 3 appear to be from *Bysakee*, or mixed *Bysakee* and *Katkee* stick-lac No. 2 seems to have been partly washed, No. 3 not. They both partake of the quality of one of our by-products, *viz.*, *Molumma*, and I cannot say whether they would fetch more than ten or twelve rupees as *Molumma* in the bazar here. They are what natives like for mixing with fairly good seed-lac for making the T. N. mark, and they might fetch the price mentioned for this purpose, but they are of no use to us for any of our present marks. I should imagine from their appearance that the stick-lac from which they were taken was either somewhat old or else partly blocked."

134. "The collection of lac in Saharanpur and its conversion from stick to seed-lac is an expensive work, small quantities costing as much as its value in the market. If there is a larger supply, it could probably be collected for from R10 to R15 per maund of stick-lac.

Lac Destroyed by Heavy Rains.

"Mr. A. P. Grenfell and Forest Ranger Puncham Singh made considerable attempts to 'cultivate' lac in Saharanpur, and in December 1892 and January 1893, I and the Forest School students were able to see several flourishing colonies on *Dhak* trees at Rampur. The experiment was to have been continued on a larger scale and we hoped before long to have a considerable amount 'planted,' but unfortunately the wet spring and hot weather and the heavy rains of 1893 had the result of killing off not merely our planted colonies, but also the lac insect in the forests, and this last year we have not been able to collect *any* at all. *We have not even been able to get* a few small quantities to place on the trees near the Rampur Range House, and if we are to continue cultivation we shall now have to obtain our 'seed' from elsewhere. I shall be glad of your advice as to the best place to get it from as I should like to try it again if only as an educational matter to show the Forest School students how lac is produced and collected and used. I am afraid that even the Saharanpur Division is too cold and at some seasons and in some years too wet for it to be worthwhile to grow lac on a large scale, and that consequently little can be done in this Circle to encourage trade in it beyond growing it experimentally so as to teach students and others what the process is, and that it is really very easy in suitable place and climates."

Statement by* Harsukh *and* Ghanesha Khatik *of Jawalapur District, Saharanpur, who grow lac in the village forests of Alipur, Chandpur and Burhampur, etc., near Jawalapur, dated 25th November 1896.

135. "The seasons for propagating lac seed are October and July, the latter being more favourable. The twigs with old crude lac are

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tied on the branches of fresh *Dhak* trees (**Butea frondosa**). From four to eight twigs are tied on each tree according to its size and foliage. The seed then spreads on all the branches and twigs in about a month, and it is often carried to other trees by the help of the wind. The twigs with lac seed should be tied up while green, for if they dry up the lac, insect would die and become inactive."

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"Lac seed put out in October yields crude lac in June, and that put out in July yields in October. The twigs are cut down and twisted with the hand by which means the crude lac is at once separated. This crude lac is then sold either as it is, or compressed into a compact mass by putting it out in the sun in a basket lined with leaves and by pressing it down when softened"

136. "Shawl merchants from the Panjab often purchase the crude lac for colouring woollen and other cloths, and it is also used by tanners for imparting colour to hides. Other uses are not known here. The local selling rate varies from R10 to R40 per maund in different years according to production and demand."

Lac Dye for Wool.

"For preparing refined lac for varnish and sealing, etc., the crude lac is washed several times in water, and fine shining grains are obtained, which are then melted and formed in various shapes. This lac sells at R40 to R100 per maund. The refined lac is not, however, prepared locally as a rule."

137. "The production of crude lac per tree varies from [illegible] to [illegible] seers, according to the size and foliage of the tree and to the seasons being favourable or otherwise. The yield is generally greatest in the autumn in the October crop, probably on account of foliage of the *Dhak* trees being better and more tender. The summer crop collected in June is usually smaller."

Yield

138. "Too much or too little rain retards the growth of lac as well as forest fires A kind of flying insect with wings like a butterfly eats up the lac, also a kind of spider eats up the whitish parts. These insects are killed by the lac growers."

Pests.

139 "Lac is rarely found in the Government forests and is grown on a small scale on *Dhak* trees only in some private lands. Experiments to grow lac in Government forests at Ranipur have hitherto failed Further experiments will be made next July"

Central Provinces.

140. Following the course already pursued with other provinces it may be useful to furnish a selection from the more important published reports and official correspondence in exemplification of certain historic facts and of the extent of present knowledge regarding the production of lac in these provinces. The following passages taken from the District Settlement Reports may be viewed as interesting in

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that they mark the position of the industry 20 or 30 years prior to the more recent and fuller reports that are now available :—

Bilaspore District.

Extract from the Report on the Land Revenue Settlement of the Bilaspore District, Central Provinces (pages 77 and 87) by* J. W. Chisholm, *1869.

141. Of industrial products the most extensively in demand is lac . . . .

The *kusam* trees on which it is found yield from 20 to 30 lbs., a portion being left for seed, or, in other words, to reproduce the material in demand, and the annual value of a tree runs from 3 to 4 rupees. As a consequence the '*kusam*' is very rarely cut down and is invariably preserved as a valuable property."

"The lac trade represents an important item, the average export of the last four years being nearly 15,000 maunds, aggregating a value of about two and-a-half lakhs of rupees. This is not, however, entirely [illegible]

agents of firms at low rates, and must yield a large profit to the purchasers compared with the small returns the actual collectors receive. No mere local resident, however, has found it a remunerative process to export on his own account, the manufacture of the dye being almost a monopoly. The whole business therefore is carried on by agents on the spot who despatch the commodity at the instance of the firms employing them. The expansion of the trade is not a likely contingency, as the demand fluctuates and the '*kusam*' trees on which the lac insects are fostered are somewhat limited in number.

Raipore District.

Extract from the Report on the Land Revenue Settlement of the Raipore District, Central Provinces (pages 76 and 77) by* J. F. K. Hewitt, Esq., B.C.S., *1869.

Season and Method of Propagation.

142. The lac trade owes its origin to the Mirzapore and Jubbulpore merchants who export yearly large quantities from Raipore. It is chiefly produced on the *kusam* and *palas* trees, but the produce of the former is twice as valuable as that of the latter. The mode of propagation on both trees is similar but takes place at different seasons of the year; the propagation of the most important crop, that of the *kusam* lac, is begun at the end of January or February. At that time freshly-cut sticks, on which the lac insect has made its cells, are wrapped in bundles of grass and tied on to the branches of the tree on which the new lac is to be grown, four bundles being generally the complement for one tree; and from these centres the insects propagate themselves in all directions, covering all the smaller twigs with their excretions. The crop is collected in the month of November or December following the sowing, and the yield very much depends upon the quantity of rain: the light

Influence of Rain

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rains bringing a light crop The process of propagating lac on the *palas* tree is similar to that described above, except that the process is begun in September and October and the crop gathered [illegible] CULTIVATION IN THE CENTRAL PROVINCES.

[illegible] nds, [illegible] crop [illegible] live [illegible] these Rates. [illegible] get very large profits on the prices paid to the producers, and at other times they hardly pay their expenses. The price in the jungles varies from 15 to 35 rupees per *bhoja* of 12 maunds and 16 seers each, and that paid by the merchants from about 25 to 80 rupees. But though it may occasionally happen that the middlemen may make a bad bargain, the writer believes that, as a rule, they generally make a very comfortable profit.

144. One of the most interesting papers on the subject of the lac industry of the Central Provinces is the account furnished in 1875 by Mr. J. McKee of the Forest Department. This not only gives full particulars as to the local methods of production and the extent of the trade but publishes the results of highly instructive experiments performed under Mr. McKee's personal supervision. More recent experiments conducted at the instance of the Inspector-General of Forests may be said to have carried the enquiry down to within the past few years. Mr. McKee's paper appeared originally in the *Indian Forester* (Vol. I., page 269 (1876), was partly republished by Mr. J. E. O'Connor in the revised edition of his most admirable work on *Lac Production, Manufacture and Trade* and has thus been before the public for many years I shall accordingly content myself with quoting only the more instructive passages from Mr. McKee's report and I do so with a view to exhibit his personal opinions and the extent of his investigations:—

145. "At present nearly all the lac is collected by private individuals from the unreserved and private forests; in the former the right being sold annually to the highest bidder, while in the latter most of the large firms interested in its manufacture have obtained leases ranging in periods from 8 to 10 years—a tenure which gives them the opportunity of increasing by cultivation the ordinary natural yield. It is well known that large sums of money, amounting latterly to about 15 lakhs annually, are circulated throughout the Province in the collection and manufacture of this material, much of which, as before stated, is [illegible] but strange to say, in spite o[illegible] most available minor forest [illegible] time reaped any considerable [illegible] than R15,000 per annum." Extent of Trade.

Discussing the question of State cultivation Mr. McKee wrote:—

146. "With regard to the cost, this will necessarily vary with the description of the trees employed for the purpose, and the proportion[illegible]

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they bear to one another in numbers on a given area. Such trees as *palas* (Butea frondosa) and *ber* (Zizyphus Jujuba) which are of comparatively small size, and which are found in many places in a state of almost pure forests, will necessarily cost less to bring

...am (Schleichera
...pal (Ficus reli-
...about the forests

or fringing the slopes of ravines and the banks of the rivers for less brood lac will be required for their treatment and less trouble and time employed in searching for them; but, on the other hand, the larger outturn obtained from the latter species will more than repay the extra money expended in preparing them. Our experiments extend at present to having operated on 7,467 trees of the *Palas* and smaller species and 1,003 trees of *Kusum*; these numbers represent the standards on which the insects are doing well and do not include a large percentage which turned out failures. The

Experiments in State Cultivation

...rges,
...erage

Cost.

Hot winds.

147. "Owing to the dryness of our summer and the great damage to the lac caused by the hot winds, it does not seem probable that we can look forward to even two good crops in the year; the summer one will probably in almost all places, except those where favourably situated, be of poor quality and quantity of lac developed not more than sufficient to leave on the trees for producing the crop which matures during the cold season. This latter will generally be good and must be the one we depend on for a return. Reckoning, then, on only one crop a year, and estimating the yield per tree at the moderate quantities of 3 seers for *Palas* and 25 seers for *Kusam* or trees of like size, we obtain a net outturn, after deducting 25 per cent. for wastage in drying and packing, from the *Palas* and small trees of maunds 5.25 per 100 trees, and from the larger species of maunds 27·32, which, if valued at R15 and R20 per maund, respectively, will be worth R84-6 for the former, and R541 for the latter. Take from these sums the cost of producing the article, which in future will be, if anything, less than heretofore, owing to the lac being obtained in one spot, and the net profits on 100 trees of *Palas* will equal R81 and on the same number of *Kusam* R526. Large areas of forest are now available on which the number of *Palas* and other suitable trees per acre quite equal or even excel the above unit, and the expediency of forming plantations of *Kusam*, which area for area would yield a more valuable crop, is under consideration."

Yield.

148. Mr. McKee gives a list of 17 trees as those on which the lac is generally found. These have been included in the combined enumeration, para. 64, which represents the good plants of the whole of India. Mr. McKee then remarks —"Of the above trees the light

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standards; but as the *Palas* is generally found in much greater numbers, area for area, its produce will nearly compensate in quantity for the reduction in its value. Having selected the forest for experiment, the next point to fix on is the local date on which the insects leave the parent cells, a step of great importance, and one on which the first success of the plantation will very greatly depend as, should the work of gathering brood lac be delayed until visual proof of the exit of larvæ is obtained, a vast quantity will be killed in the operations of collection, transport, and of tying the encrusted twigs on the standards selected for nurseries. The date of evolution having been fixed on with some certainty, twigs of that season's lac should be gathered about 15 days before, wrapped up in a few straws of grass and attached to the trees selected for production, with threads of *Palas* root fibre or something else as easily obtained; each twig should be from 9″ to 1′ in length, and be attached to the upper and

Varying Properties.

Method of Propagation.

nourishment; as owing to the crookedness and irregularities of the encrustations contact between them and the branches is seldom complete. *It is also of importance to tie the brood lac to the upper* and middle branches, as many of the lower ones, by this arrangement, become covered with insects, which are shaken or fall from above; whereas if the lac be attached to the lower portion of the tree, many larvæ must fall to the ground and be lost; when attaching the twigs it appears *necessary to take care that the wood of* the standard is not of denser composition than the wood of the tree from which the brood lac is gathered, as it is believed that the larvæ reared on soft-wooded trees are comparatively weaker than those which are found on species of harder texture. There is an idea prevalent among the Gonds that nursery standards must be prepared with brood lac taken from the same species as themselves, but this has been proved to be incorrect The brood lac yielded by the *Kusam*, a very hard wooded tree, appears best suited for propagating purposes, as it succeeds on trees of all other species When several trees of the selected species grow together it does not *appear necessary at first to artificially* cultivate more than three-fourths of them, as during the succeeding evolution the remaining fourth will almost certainly be brought under preparation by natural means,* but as the success of the crop depends principally on the supply of juices obtained by the female insects during the period they continue to deposit the resin, *it is necessary to place the brood* lac on the youngest and most sappy branches."

Position of Attachment.

Natural Reproduction.

to its being a bad crop, but was left for further propagating purposes. On the 19th August, however, an enumeration of the trees on this spot proved that new lac was then being formed on 1,380 trees; thus 509 trees must have been affected by their proximity to the old standards."

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149 "Lac preserves may be formed by carrying out the above simple operations; but it is not probable that success will be attained at once or until experience has drawn attention to several peculiarities in the habits of the insect and the manner in which it is influenced by situation and atmospheric conditions. Our first attempts were made in the cold weather of 1874, but owing to the want of knowledge that prevailed on several essential points, both among the superintending staff and the labourers employed on the work, the extent of these was naturally limited and of small result. It was not known with any certainty when the exit of young larvæ commenced or what was the best method of applying them to the trees; thus a large number were lost, and this destruction of insect life was greatly increased by the rough handling they were exposed to by the workmen In one instance a plantation which had been prepared and was progressing well was nearly destroyed by mistaking an evolution of male insects for one of larvæ,—an error into which it would not be possible to fall except through want of knowledge of the insect habits, in another, the colonies were greatly damaged by a fire which broke out and destroyed the lac—on all but the highest trees, while in a third, frost and hot winds killed the females and stopped the formation of lac on nearly half the number of trees prepared But although we had to contend with so many mishaps, partly through ignorance and partly from physical causes, each experience in its way brought valuable information which will render more certain our future undertakings"

Male Insects. *Conf. with p. 11,*

Propagation Sticks or Brood Lac.

150. "Of the points to be noted in making these *preserves*, the one of the greatest importance perhaps is the fact that the lac encrustations may be plucked several days before the larvæ appear,—a knowledge of which will enable a larger number of trees to be prepared during the working season than if it was necessary to delay the operations until the evolution actually took place, as, owing to this latter being barely simultaneous in and about one locality, the period for forming the plantation must be necessarily limited to the number of days it takes the cells to become empty; besides which, by attaching the lac twigs before the birth of the larvæ great numbers are saved, which would otherwise perish during the process of being attached to the trees In support of this fact it will be interesting to give the following observations: Mr Thomson, Deputy Conservator, in order to fix on a safe date for gathering the brood lac, caused twigs, covered with the encrustation, to be brought [illegible] ery two days for examination. [illegible] in the verandah of his forest [illegible] on the 10th June, and the [illegible] il the 12th July. These [illegible] and were brought from [illegible] 10 miles; some were [illegible] *Pipal*, but the majority [illegible] 3th July, according to [illegible] ut found no sign that the larvæ had vacated their cells although microscopic observations

Survival of insects after Separation of twigs.

had proved them to be fully developed. On the 14th, however, an inspection showed that on all the twigs without exception, the young were pouring out of the cells through the anal apertures; thus the twig gathered on the 10th June hatched exactly on the same date as the one gathered on the 12th July, or more than a month later." "While on this subject it is necessary to draw attention to the reported variation in the number of evolutions and consequently in the number of crops which are obtained in different countries. In Mysore and Burma it would appear that three evolutions of the insects take place during the year." CULTIVATION IN THE CENTRAL PROVINCES.

Discussing the influence of climate Mr. McKee says:— Climate.

151. "This no doubt is the reason why in districts where the seasons are dry and where showers are of unfrequent occurrence during the hot weather, the summer crop is invariably poor and scarcely worth collecting. Moisture is one of the great essentials for a fine crop of lac, and many disappointments, if not total failure, will result by fixing on dry arid spots for the formation of the plantations. The females cannot obtain sufficient nourishment at this period from the sapless stems, and their death will be recognised by the pitted appearance assumed by the cells, the crowns of which fall in as the insect contracts within them, and by the cessation of the growth or disappearance of the white filaments which obtrude from the spiracular orifices, species such as *Kusam* and *Guler*, which most frequently are found growing along the banks of rivers, where the atmosphere is humid and moist, are, for these reasons, especially adapted for yielding good crops of lac; while the *Palas* offers advantages, as its sap-producing functions are actively employed during the hottest season of the year when it forms both new wood and leaves." Necessity of Moisture. Death of Females.

The Conservator of Forests, Central Provinces, Nagpur, furnishes the following instructive particulars in a letter, dated 8th January 1894, to the address of the Inspector General of Forests:—

152. "With reference to your demi-official Circular No. 1 of the 3rd January 1894, I have for the present to communicate the following remarks and information:—

"Some years since the production of lac was taken up departmentally; it proved very successful, was supplemented by much spontaneous production, and proved highly profitable, for the prices had then run up to the highest figure attained, a fact due, it is believed, to the whole of the stock in the London market having fallen into the hands of two or three individuals who worked together After this came the crash and the price of lac fell so low that the artificial production for a time ceased to pay. It again revived to some extent; but it has to contend with varying climatic conditions and for one or two years these have been altogether against the production of lac." Rise in Prices.

CULTIVATION IN THE CENTRAL PROVINCES.

153. "For the last three years I have been struggling to encourage production in the Eastern forests of this circle, where there is a good deal of Schleichera trijuga which yields the finest lac both as regards its quality and capacity for standing storage; but it has been impossible to obtain any supply worth mentioning of good seed lac and consequently little or no progress has been made"

Failure.

154. "During the year 1891-92 the insects appear to have completely disappeared from the Government Forests of Raipur and Bilaspur, and I have been addressed by a private firm, in the habit of drawing their supplies from private forests in that region, enquiring whether or not there was truth in the report of the sudden failure of the crop in that part of the country."

Forest Villages are necessary for obtaining much lac.

155. "It is worthy of note that while this almost total failure occurred in Chhattishgarh, an unusually good crop was obtained along the base of the Satpura hills, about 60 miles north of Nagpur. There can be no question that the lac industry is a somewhat precarious one, but it is equally certain that this, as well as other industries, . stronger establishment ed by people, who doing supply of grain, devote the rest of their time to forest work. But the establishment is at present altogether insufficient, and though for this also the local officers are not responsible, the organisation is most defective, and though it may save a few rupees, is not economical, and here I may note that I only regard that organisation as economical which will bring in the largest return per cent. on the outlay incurred."

Experimental Cultivation of Lac in the Central Provinces. Forest Administration Report, Central Provinces, 1894-95 and subsequent issues.

Experiments conducted.

156. In Bilaspur, in the Kuajathi-Pantora Range, seed lac was placed (1894-95) on 100 *palas* and 50 *kusam* trees. It is reported to have succeeded on the former, but to have failed on the latter, owing to heavy rain, which swept the insects off the trees.

Heavy Rain.

In Chanda, during July 1894, an area of 4 acres was chosen in the Moharli Range and brood lac tried on 100 selected *palas* trees. The undertaking was quite successful; so last June the experiment was extended to 60 acres in the Moharli Range and 450 acres near Ragri in the Warora Range, 396 trees being prepared in the former and 200 trees in the latter at a cost of only R17.

The results of this experiment will be watched carefully and reported on next year

Reports of Results attained.

157. In Betul, lac was propagated over a wide area, and the Divi- ... ır experiment ... anda Division ... been favour- ... cultivation, in

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consequence of a very small quantity c...
453 trees on 22 acres were operated o...
which yielded lac valued at R5-8-0.
nection resulted this year also in the Warora Range. District.)

158. For the year 1896-97, (page 18—Northern Circle) it was reported:—The opportunity given by the cancellation of nearly all the lac leases in consequence of the forests having been thrown open to all-comers in search of edible products, etc., was seized to undertake propagation by departmental agency. The remarkable financial success scored by the Rewah State in the exploitation of lac proves beyond doubt that the business is capable of very great expansion in this Circle, especially in the Mandla and Jubbulpore Divisions, in the Satpura portion of the Narsingpur and Hoshangabad Divisions, and in the moister parts of the Betul Division. Results attained in Rewah State.

In Mandla nothing could be done as seed lac was not procurable In Jubbulpore experiments were successfully carried out in the Marwara, Sihora and Jubbulpore Ranges. In Damoh 800 *ghont* and *palas* trees were sown at a cost of R100. In Saugor experiments, costing R4-1-6, were tried in the Jaisinghanagar, Jamunia and Oria forests, the results so far being satisfactory in the first two forests and a complete failure in the third. In Betul work was undertaken on a considerable scale, although without expenditure; but the long drought that prevailed and hot winds proved fatal when the insects had made some progress.

159. For the year 1897-98, (page 27—Southern Circle) it was reported:—In the Chanda Division, it is reported that the lac experiments showed very unfavourable results. Trees 84, over two acres, were operated upon at a cost of R1-4-0, the lac obtained being 1 seer. Want of brood lac prevented more trees being put under cultivation. The Forest Divisional Officer believes that this industry has a good future before it, if fostered by care and supervision, to the want of which he ascribes past failures. The matter will receive more attention.

Berar.

160. The following series of letters and reports give the latest available information regarding the experiments performed to extend the production and trade in lac in the Hyderabad Assigned Districts (Berar):— CULTIVATION IN BERAR.

Copy of letter No. 217, dated the 9th July 1894, from the Conservator of Forests, Hyderabad Assigned Districts.

161. I have the honour to thank you for your demi-official Circular No. 1, dated 3rd January 1894, and for the hints therein given regarding the advantages of lac culture.

I beg, as requested, to put up a memorandum noting the information I have been able to collect regarding lac in Berar, giving my

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opinion on the subject and detailing action taken and proposed to be taken, in connection with the extended culture of this valuable minor product of our forests :—

"Enquiries regarding the *propagation* of the lac insect and the present sales of lac from Berar have been made on the Inspector General of Forests' demi-official Circular No. 1, dated 3rd January 1894.

162 "It appears there is little or no culture of lac in Amraoti, Akola and Buldana, and there are no facilities for starting the culture.

Royalty.

"In the Ellichpur Division there is a considerable export of lac; as the royalty levied does not exceed 6 pies a seer and R978-7-6 being the collection of the last year, the outturn must have been near 800 maunds In the Melghat Forests of this Division there are facilities for cultivating lac in the fire-protected forests on *Palas*, *Pipal*, *Ber* and *Kusam* trees, and it is proposed to start work through the Kurkus, an aboriginal race, already accustomed to collect lac.

"There seems to be no reason, why the price charged for lac should not be raised.

163 "In the Basim Division lac is found in the Kinwat Reserve, and the right to collect has hitherto been sold by auction. In 1893 the right was auctioned for R20 only, but enquiry shows that the export certainly amounted to 40 maunds, so that even at Ellichpur rates R50 should have been realized.

"The presence of forest villages of Kols and other wild tribes in Kinwat render it easy to extend the culture of lac, and it may be well for one or two seasons to pay for culture and collection, and sell the outturn in bulk departmentally.

164. "In Wun Division there have hitherto been only nominal [illegible]

Profits

[illegible]

3 maunds 26 seers of stick lac, noted as 2nd quality by the Agents which sold by auction for R87-9-6. Deducting the carriage by rail [illegible]

"It is proposed to cultivate lac in the Kelapur, Anjankher and Lonbehel fire-protected reserves of the Wun Division, where there are facilities as to suitable forest growth and labour for cultivation and collection

165. "As to Berar in general it may be said that lac has hitherto received no attention, that there are facilities for extending the cultivation and collection of this valuable product, and that apparently sales of lac should rise to many thousands a year within a comparatively short period of time. Whereas in Berar we have so many reserves under recuperation which at present give no direct

CULTIVATION IN BERAR.

returns, the culture of lac may enable us to create a new source of revenue, and at the same time increase wage-earning in the wilder and poorer parts of the country.

"Four points are :—

Prospects of Increased Production.

1st.—No land has hitherto been set aside for lac culture, and only the outturn of spontaneous production has been exported.

2nd.—There appear to be facilities for largely increasing the production of lac, but I cannot estimate the probable area or outturn.

3rd.—I can give no figures as to the annual ratio of increase.

4th.—The culture of lac only affects the least valuable part of our forest growth, and I know of no objections to extended and systematic cultivation of lac.

166. "As to conditions under which cultivation might be carried [illegible] the malarious [illegible] are, very easy [illegible] ike to produce [illegible] ninimum sum per annum by way of profit."

Memo., dated 26th May 1897, on Lac Culture and Sales in Berar by the Conservator of Forests, Hyderabad Assigned Districts.

Review of Recent Experiment

167. "The most extended experiments as to lac culture have been made in the Ellichpur Division and a memo. (enclosure No 1 (*see* p 250)) on the subject, by the Deputy Conservator of Forests in charge, is attached.

"In the Amraoti Forest lac culture has only just started and it is too early to quote results. The yearly sales from old lac are *nil.*

"In the Akola Forests culture is being started in 1897-98. The average annual receipts from naturally grown lac are only R22-8-0.

"In the Buldana Forests lac-bearing trees are few in number and lac culture could not pay.

"The Basim Forests are most promising as to lac culture. A note on subject by the Divisional Officer is attached (enclosure No. 2 (*see* p. 256)).

"In the Wun Forests the progress to date is disappointing. A memo. (enclosure No. 3 (*see* p. 257) by the Divisional Officer is attached.

Climatic Conditions Necessary.

168. "In the years 1895-96 and 1896-97 the early rains were heavy, but the later rain failed and from September onwards in each year there was drought. Lac culture seems to demand normal moisture and during these two years the 1894-95 experiments which promised success have failed. The lac sales have, as might be expected, fallen off.

CULTIVATION IN BERAR.

"The receipts for all forests in Berar were :—

	R
1893-94	567
1894-95	2,489
1895-96	2,052

and 1896-97 will be worse.

"I believe, however, lac will pay and experimental culture will be pushed."

ENCLOSURE NO 1

Note on Lac by* Mr. R. M. Williamson, *Deputy Conservator of Forests, Ellichpur Division.

Experimental Cultivation.

169. "The details of the species of trees experimented with and the expenditure and revenue from lac are given in the 4 forms attached. Form No. 1 (*see* pp. 252-253) shows the lac cultivation in 1894-95, 1895-96 with species of trees in each range.

"The Rangers report that the largest percentage of success was obtained on *Palas* (Butea frondosa) and *Ghatber* (Zizyphus xylopyra), but no definite figures are available, small success was for some reason met with in stocking trees of other species, the lac spreading a short distance and then dying off This may have been due to climatic causes

"Form No 2 (*see* p. 254) shows the expenditure on departmental cultivation and collection of lac with the price at which it was on the spot (*i e*, at certain centres) in Bairagarh and Gugamal sold by tender Reserves in 1894-95 and 1895-96, respectively

First Year Poor Return.

170. "The departmental collection of lac was not entirely from trees departmentally stocked in the two years, but included some from previously existing sources. This and the fact that the lac does not spread very far in the first year after stocking and consequently does not give immediate return for the expenditure, render impossible any useful comparison of the figures of expenditure and revenue as quoted in the Form. A greater length of time must elapse before a definite estimate of the possible financial results can be made

"Form No 3 (*see* p 255) shows the total revenue from lac in Gugamal and Bairagarh Reserves from 1893 to 1895-96, whether departmentally collected or by purchaser.

Prices

"Form No 4 (*see* p 256) shows the revenue from lac from CIII Forests paid at the forest sale depôts at the rates noted respectively. It is exported as stick lac and is understood to sell in Ellichpur market at 4-5 annas per seer, the supply being eagerly bought up, whereas the lac collected departmentally and sold by tender for the whole —fetches only R1 for 9 seers, in the case of stick lac, and R1 for 4½ seers, in the case of seed lac, in the Reserves.

171. "As to the future prospects of the lac cultivation it is to be hoped that as the results of artificial cultivation make themselves more marked (the lac spreading in the course of nature to surrounding trees as well as on the actual trees stocked), and as greater skill is

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attained in the process of attaching the lac, that a much larger return will be obtained. Much depends, however, on the cost of collection and the price obtainable. Hitherto the wages paid for collection of seed lac has varied from $1\frac{1}{2}$ annas to 2 annas per seer, while for seed lac it has ranged from 2 annas a seer to R1 per 5 seers It is hoped that $1\frac{1}{2}$ anna for stick lac and $2\frac{1}{2}$ annas for seed lac may be found sufficient.

Difficulties of the Trade.

172 "Also, as stated in paragraph 5, the prices obtained by departmental sale leave much to be desired. As an experiment the District Forest Officer this year refused the only tender received (the same in amount as that last year) and has decided to sell stick lac from the Reserves in the open market in moderate quantities by public auction. Unless better prices can be obtained the margin of profit will remain very small. The experiment is, however, only commencing and it is too soon to form any accurate idea as to the future results. The experiment is, however, in the District Forest Officer's opinion well worth continuing"

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PRODUCTION IN BERAR.

FORM No 1.

Cultivation of Lac in 1894-95 (Forest Year).

Year.	Month when Lac was put on the trees.	Number of trees on which Lac was placed.											Total No. of trees.	Cost.
		Palas.	Kusamb.	Ghoti.	Pipal.	Ber.	Bur.	Tiwas.	Salai	Lendya.	Gular.	Feper.		
1894-95.														R a. p.
Sembadoh Circle . . .	June 1895 .	No detail is available.											5,467	17 12 0
Chaorakund " . . .	Ditto .	19,413	277	1,503	143	2,043	6	...	...	..	.	..	23,385	37 12 0
Butram " . . .	Ditto .	19,662	833	3,693	30	6,350	52	...	...	...	353	37	31,010	44 1 0
Khandu " . . .	Ditto .	2,378	628	771	...	78	...	...	...	...	15	...	3,870	6 6 0
Gugamal " . . .		4,620	1,836	1,780	146	782	...	1,113	4	8	...	...	10,289	86 6 0
												Total .	74,021	192 5 0

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PRODUCTION in BERAR.

FORM No. 1—*contd.*

Cultivation of Lac in 1895-96 (Forest Year).

Year.	Month when Lac was put on the trees.	Number of trees on which Lac was placed.									Total No of trees.	Cost.		
		Palas.	Kusamb.	Ghoti.	Ber.	Tiwas.	Gular.	Pakar.	Pipal.	Bur.		R	a.	p.
1895-96.														
Sembadoh	June 1896 . .	6,485	3,909	5,246	5,105	4,000	...	20	9	60	24,834	28	11	0
Chaorakund	May 1896 . .	2,514	146	...	...	...	.	...		...	2,660	7	4	6
	June 1896 . .	2,200	50	...	.	..	...	...	...		13,480	26	2	0
	Ditto . .	8,687	370	2,066	35	...	70	...	1	1				
Butrum	May 1896 . .	10,282	500	2,400	4,800	..	..	...	25	600	18,607	44	10	0
	June 1896 . .	7,816	533	1,493	2,050	...	53	17	30	52	12,044	12	2	0
Khandu	Ditto . .	15,200	2,320	1,949	1,320	300	...		...	...	21,089	21	12	0
Gugamal	November 1895 .	571	128	714	370	944		..	...	...	2,727	20	0	0
										Total .	95,441	160	9	6

PRODUCTION IN BERAR.

FORM No. 2.

Statement showing Amount spent in Cultivation (attaching Lac), Collection and Sale Price.

Year.	Amount and cost of cultivation—(attaching).		Amount and cost of collection of Lac.			Sale price.	Remarks.
	No. of trees.	Cost.	No. of seers collected.	Cost per seer for collection.	Total cost.		
		R a. p.		R a. p.	R a. p	R a. p.	
1894-95 . . .	74,021	192 5 0	520	0 1 6	46 12 0	130 0 0	
1895-96 . . .	95,441	160 9 6	(a) 614½ (b) 263	various 0 2 0 to 0 3 0	141 9 6	168 7 10 29 3 2	(a) Seed-lac. (b) Stick-lac.

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FORM No. 3.

Statement showing Sale of Seed-lac and Stick-lac in Bairagarh and Gugamal Reserves from 1893-94 to 1895-96.

Year.	Reserve and range.	No of seers collected.	Cost of collection		Price obtained			Remarks.
			Rate per seer.	Total.	Rate	Per	Total.	
				R a. p	R a. p.		R a. p.	
1893-94 .	Bairagarh .	(a) 164 Head load	Collected by exporters.	...	0 6 0	Head load.	61 8 0	(a) Stick-lac. (b) Seed-lac.
	Gugamal .	(a) 19 Ditto		...	0 6 0	Ditto	7 2 0	
1894-95 .	Bairagarh .	(b) 520 seers	Ro-1-6 per seer.	48 12 0	0 4 0	Seer	130 0 0	
	Gugamal .	(a) 317 Head load	Collected by exporters.	...	0 6 0	Head load	118 14 0	
		(a) 56 Ditto		...	0 6 0	...	21 0 0	
1895-96 .	Bairagarh .	(b) 459½ seers	5 seers to a rupee	118 12 0	4½ seers	Rupee	131 5 4	
		(b) 25 Ditto			0 4 0	Seer	8 4 3	
		(a) 263 ...	11 seers to a rupee		9 seers	Rupee	29 3 2	
	Gugamal .	(b) 130 seers	Ro-2-0 per seer.	16 4 0	4½ seers	Rupee	28 14 3	

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PRODUCTION IN BERAR.

FORM No 4.

Revenue from Lac (stick-lac) in 1893-94 to 1895-96.

Year.	Quantity.	Rate.	Revenue.		
			R	a.	p.
1893-94	13 Cart loads . . . 22 Bullock loads . . . 24 Donkey loads . . . 545 Head loads . . .	...	303	6	0
1894-95	11 Cart loads . . . 30 Bullock loads . . . 12 Donkey loads . . . 809 Head loads . . .	...	394	6	0
1895-96	13 Cart loads . . . 11 Bullock loads . . . 6 Donkey loads . . . 814 Head loads . . .	...	384	8	0
		TOTAL .	1,082	4	0

ENCLOSURE No. 2.

***Note on Lac in the Basim Division by* Mr. C. H. Haldane,**

Divisional Forest Officer, Basim Division.

Results of Experiments

173. "The monopoly to collect lac in the Kinwat and Marwadi Reserves was sold in 1893 by auction for R20 and R12, respectively, but it was noticed that the Reserves could yield a very much larger quantity with culture. Consequently in 1894-95 its culture was undertaken and the insect attached to 4,650 trees in Kinwat and 2,434 trees in Marwadi, the work costing R7-2-0 and R15, respectively. The result in the former case was a success as the figures given below will show, but not in Marwadi owing to the small extent of '*tiwas*' on which the insect is usually found in these parts.

"In 1895-96 propagation was only undertaken in Kinwat where it cost R15-8-0, but the yield was comparatively poor owing to the excessive dry heat of the last hot season by which the insect was almost exterminated as was seen from the collections made in June last.

"Of the other areas Gahuli alone, where culture is contemplated this season, the lac insect is noticed to a small extent.

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174. "The outturn of lac during the last three forest years is as follows:— Outturn in Berar.

Year.	Quantity in seers.	Average rate per maund.	Value.	Expenditure.
		R. a. p.	*R. a. p.*	*R. a. p.*
1893-94		Auction	32 0 0	*Nil.*
1894-95	2,491	20 8 0	1,280 0 0	175 0 0
1895-96	1,997	15 8 0	750 0 0	113 0 0

"As regards the future prospects of lac, the Divisional Forest Officer is of opinion that there is no reason why the outturn in a few years in Kinwat should not double itself with annual culture and proper supervision during collection. Also in Gahuli State Forest he is of opinion that lac could be successfully propagated. Prospects.

"In Marwadi prospects are poor for want of more '*tiwas*' and other trees on which the insect usually thrives."

ENCLOSURE No. 3.

Note by Mr. Mansukh Ilal, Divisional Forest Officer, Wun Division.

175. "In 1894-95 lac cultivation was attempted in the following Reserves:—

Kelapur	Reserve about	2,000	Acres.
Anjankhed	do. do.	2,000	"
Pathroat	do. do.	500	"

"In Kelapur propagation of lac succeeded fairly well, but in Anjankhed and Pathroat the experiment was a failure. Only a very few trees were seen doing well. In 1895-96 no work under this head was undertaken. In the current year, too, it is reported by Rangers that owing to scanty rainfall lac seed is very scarce and any, if propagated now, is not likely to succeed. Wun.

"The receipts have been as follows:—

	R.	*a.*	*p.*
1893-94	163	3	0
1894-95	519	8	0
1895-96	700	0	0

"During the current year 1896-97 receipts are not expected to reach R500.

"Lac is chiefly found in the Kelapur Taluk

176. "In my opinion the past experiment has been a failure No proper information was recorded by the Foresters, etc. Now that we have got intelligent establishment the experiment will be

CULTIVATION IN BERAR.

regularly made and results recorded in a separate note book supplied to each Ranger for the purpose. I think the lac cultivation will be a paying concern in the Wun District."

Central India and Rajputana.

177. Very little is known regarding the production of lac in these regions. That there must be a considerable trade in the product is abundantly demonstrated by the high perfection to which the art of ornamentation with lac has been carried.

CULTIVATION IN CENTRAL INDIA.

178. Forsyth (*Highlands of Central India, published 1872*) alludes repeatedly to the substance and the trees on which it is produced. The following passage from that work may, therefore, be read with interest :—

"Stick-lac of commerce is deposited by an insect on the smaller twigs of several species of trees among which **Butea frondosa, Schleichera trijuga** and ***Zizyphus* Jujuba** are the principal. The twigs are broken off, and sold as they stand, looking like pieces of very dark red coral. About twenty pounds will be procured annually from a tree, so long as any of the insects are left on it to breed. But just as often as not the improvident wild man will cut down the whole tree to save himself the trouble of climbing. The inborn destructiveness of these jungle people to trees is certainly very extraordinary; even where it is clearly against their own interest, they cannot apparently refrain from doing wanton injury. *A Gond or Byga passing along* a *pathway will almost certainly*, and apparently unconsciously, drop his axe from the shoulder on any young sapling that may be growing by its side, and almost everywhere young trees so situated will be found cut half through [illegible] consider- [illegible] gentleman [illegible] g the suc- [illegible] enterprise. The agents of this Factory penetrate the remotest corners of these *jungles in search of the raw material*; and the development of this profitable business, during many years of patient and fair dealing with these timid savages, is a valuable example to those who would follow Mr. Williams' steps in the development of the many latent resources of these regions."

Punjab.

CULTIVATION IN THE PUNJAB.

179. Although the art of ornamentation with lac has been carried to a very much higher state of perfection in the Punjab than in any other province, the production of, and trade in, the crude article has by no means attained the same position of importance as in most of the

CULTIVATION IN THE PUNJAB.

other provinces. It might be viewed in the Punjab as a local product, which is taken full advantage of in the indigenous industries, whereas with Bengal, the Central Provinces, and Assam it has from almost the earliest times of British commerce been looked upon as a valuable item for foreign export although one which is but indifferently utilised by local industries.

180. One of the earliest writers on the Punjab may be said to have been the late Mr. H. Baden-Powell, C.I.E., who (in his *Economic Products of the Punjab, 1868-72*) gave an instructive sketch of the trade in this substance. The following passages may, therefore, be usefully recorded here from that great work :—

Passages taken from the Hand-book of the Economic Products of the Punjab, Vol. I., pages 190-94, 1868, by* H. Baden Powell

Baden-Powell's account, in 1868 A.D.

181. "The lac insect is found more or less all over India; in the Punjab it is universal, and there is scarcely a district which does not exhibit a sample.

"The lac exhibited is almost exclusively the produce of one or other of the three trees '*pipal*' (**Ficus religiosa**), '*dhak*' (**Butea frondosa**), or '*ber*' (**Zizyphus Jujuba**). The *dhak* specimens have been sent from Kangra District, and also from Kapurthalla. The '*ber*' lac is the commonest; it is much produced in the Jhang and other districts, where tracts of waste land are covered with the wild '*ber*.'"

182. Having given a statement of t[illegible] lac
a [illegible] of
N [illegible] ects
w [illegible] sect
b [illegible]

[illegible] with a point of chalk. I have removed an entire piece of lac incrustation from the twig, and observed the bark underneath covered with these little white dots, one in every cell and one under every insect; under the microscope they clearly appear to be specks of a semi-crystalline saline efflorescence, at the place punctured by the insect. The [illegible]

[illegible] no means of egress save by eating through the body of the mother, which they do, feeding the while on the red colouring matter contained in her body which is thus consumed. When the young insects have regularly eaten through the

* This work was written as a Catalogue of the Lahore Exhibition of 1868.

CULTIVATION IN THE PUNJAB.

mother's body (who of course dies under the operation) they pierce the resinous coating and escape. This occurs about the month of June, as soon as the first rain clouds gather, and the lac which is collected after this yields very little colouring matter. Two gather-

Terms given to various Stages.

lakh'; this lac is treated with water, and thus the colouring matter is extracted. By this process the concretions of lac get broken up into grains or small fragments, and this forms the 'lakh dana,' or seed-lac; in this state it contains no colouring matter beyond what is indigenous to the resin. The third or clarified kind of lac is called 'chapra lakh,' or shell lac ('chapra,' a shell). Sometimes the seed-lac is merely melted into lump lac, which is used to make bracelets of."

184. Mr. Baden-Powell next gives an interesting communication from the Rev. J. S Woodside of Kapurthala relative to the lac insect from which the following passages may be abstracted :—

"About three years and half ago, or in October 1860, the Rajah's Oudh Agent sent up a man from Ikanna with about three maunds of the lac, containing the insect" "The Oudh man remained some 18 months at Phugwara and instructed the man now in charge in the science of lac cultivation. He says they took the lac from the vessel in which it came, put it into detached portions, tied up in little bundles of grass." "These bundles were tied to the larger branches of the *dhak* tree, and as the insect appeared, it found its way out from the bundle on to the branch and soon made its way up the smaller branches where it commenced its operations. This was in November. There seems therefore to be *two seasons* for its labours—the cold season and the rainy season,—the one commencing in November and the other in June. The November crop seems complete in February, and the June crop in September. It is not gathered, however, till the insect leaves it for the succeeding season."

Coldstream's account in 1881 A.D.

The next writer of importance on the lac production and trade of the Punjab may be said to be W. Coldstream, Esq., I.C.S. The following review of his opinions may be, therefore, usefully given :—

Passages taken from the Indian Forester, Vol VI, July 1880 to April 1881, pages 218 and 219, on the Production of Lac in Hoshiarpur District, By W. Coldstream, Esq., I C S, Deputy Commissioner.

185. "The district of Hoshiarpur lies between the Beas and Sutlej

plains and in the valleys between the hills. It is more abundant in the latter.

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"It affects chiefly the *Beri* (Zizyphus Jujuba) and *Kikar* (Acacia arabica).

"It is found for example, on six species of Ficus. The lac produced by the various trees differs in quality. The lac produced on the Zizyphus is deemed the best, and next to it comes that produced on *Sirris, Kikar* and *Pipal.*

CULTIVATION IN THE PANJAB. (Hoshiarpur District). Quality and food plant.

186. "There are two seasons for production,—February to April and July or August The crops are collected in June and October or November. The same tree is said not to produce two crops in the same year. The autumn or October crop is considered the more valuable of the two

Seasons.

"The artificial propagation of lac is understood by very few persons, but seems to be occasionally practised. The method adopted is to tie a small branch with the insects on it on the tree which it is desired to affect. The writer has found it very easy to propagate lac on *Beri* trees in this manner. The twigs containing cells of the insect were tied on to the trees in July, shortly after the new swarm appeared and spread over the nearest branches of the tree. There appears, however, to be among the people a great dread of the tree being injuriously affected by the spread of lac upon it, and this is probably *the reason why propagation is not carried on to a greater extent.* In cutting lac off a tree, a few twigs containing cells are allowed to remain to furnish a crop for next year.

Injury to Trees.

187. "There existed a deep and widespread prejudice among [illegible] 'ac. This was particularly [illegible] districts Saraogis). Lac [illegible] *of the tree, and to be an* unclean substanc[illegible] to account for thi[illegible] within the last te[illegible] in the market. [illegible] the Civil Courts as to the relative rights of landlords and occupancy tenants to take the lac from trees growing in an estate. The question was not discussed at the time of the Revenue Settlement of the district in 1852, lac having then but a small marketable value

Objections to the Trade.

188. "The crop of lac on roadside trees is sometimes sold by Government to a contractor, who is allowed to cut off twigs and branches of a certain thickness In 1876 the lac on the roadside trees in Unah Pergunnah was sold for more than R400. The crop, however, varies much in quantity from year to year, as does also the value of lac in the market."

189. Lac in the Gurdaspur district in thus described. "Of lac in the district there is abundance It appears chiefly on the *sirris* and *beri* tree, the insect in the course of time ruining the tree. A great deal of lac is collected during the months of January and February in the Baltion Bagh near Dinanagar, and as much as R450 to R500 a *year is paid to Sirdár Dial Singh of Majitha,* who is the *Manager* of this common on behalf of the towns people. The trees are lopped, *and the branches, after the leaves have been beaten off for fodder,* are collected and the lac scraped off. This is boiled and purified

Gurdaspur (District).

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CULTIVATION IN THE BOMBAY.

until it has been brought into a marketable state."—(*Punjab Gazetteer, Gurdaspur District, 1891-92, page 120.*)

Bombay and Sind.

CULTIVATION IN BOMBAY.

190. ***Bombay***—Very little can be learned regarding the lac trade of Bombay and Sind. As already remarked (paragraph 3), the "gum-lac" of the East India Company would appear to have been very largely obtained from Western India. Where that came from is difficult to understand since at the present day Bombay draws its supplies mainly from the North-Western Provinces and Oudh, both of stick-lac and shell-lac. Of the former the Rail-borne Trade Reports show an annual supply of a little over 1,000 maunds carried by rail to the Bombay Presidency.

191. The Gazetteers, Administration and Forest Reports, say practically nothing regarding lac. The following passage may, however, be here quoted.—

Kaira and Panch Mahals.—"The only industry of special interest is in Dobad The Lac [illegible] Dobad and largely in the forest [illegible] Rajpur, Udepur, and Devgad Ba[illegible] are the *Pipla* (Ficus religios[illegible] dosa), the *Bordi* (Zizyphus [illegible] chera trijuga)

"The lac is collected by Bhils and Naikdus, who, either for grain or [illegible] a [illegible] alr[illegible] comes to [illegible] twigs. T[illegible] stones an[illegible] its price [illegible] (R5 to R[illegible] and *bordi*, and the dearest from the *kusamb* trees. Of the whole supply only a little is locally worked up into lac bracelets. Of the rest in ordinary years about 5 tons (280 *maunds*) go to Ahmedabad and $7\frac{1}{2}$ tons (400 *maunds*) to Ratlam. In Ahmedabad the lac is used for colouring leather, and in Ratlam for making bracelets. —(*Bombay Gazetteer, Vol. III., Kaira and Panch Mahals, 1879, page 249*)

Pounded with Stones

CULTIVATION IN SIND

192. ***Lac in Sind.***—A useful paper has been communicated by Mr G M. Ryan, Deputy Conservator of Forests, dated Karachi, 18th July 1896 A few passages may be usefully abstracted in this place —

Trees on which Lac is found.—"*Babul* (Acacia arabica), *Kandi* (Prosopis spicigera), *bar* (Zizyphus Jujuba), *nrus*

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Trees on which found.

(**Albizzia Lebbek**), *banyan* (**Ficus bengalensis**), *tamarisks* (**Tamarix gallica**) are the trees on which Lac may be seen in the Province. Most of it, however, is collected from the *babul* which grows gregariously along the Indus, forming dense forests. *Kandi* in places is also gregarious, but the insect does not usually affect this tree under such conditions. On *Kandi*, it is found about 12 to 14 miles south of Hyderabad along the left bank of the Fuleli, chiefly where the two species *kandi* and *babul* are mixed, and occasionally in the Khipra Taluka in Thar and Parkar The insect does not appear to be known on this tree at all north of Hyderabad. On *ber*, *sirus* and *banyan*, it is seen mostly along road-sides and banks and canal banks. There is one *banyan* just below the Hyderabad Gymkhana on the road-side which bears a splendid crop every cold weather."

Crops.

193 *Crops of Lac.*—"There are two seasons for gathering Lac, one being in the cold weather and the other in the hot. The cold weather crop is commenced to be gathered when the northerly winds set in in November, and the gathering continues till January or February. The hot weather harvesting of the crop begins with the setting in of the south-westerly breezes in April and lasts till June. The latter, though not so plentiful, is a better crop in value than the former, realising as much as R5 per maund more. The crop on the *banyan* (**Ficus bengalensis**), however, is an exception. Its cold weather crop is both more plentiful and valuable than the summer crop. In order to secure a supply of Lac for the following year, some of the incrustation, containing of course the live insects not yet fully developed, is left on the branches of the trees at the time of gathering The period when the insect is likely to be ready for swarming out of the incrustation is well known to the gatherers, and about a month or so before this most of the produce is collected, while the remainder is left behind on the branches to form a nucleus for the succeeding crop. Those insects left on the trees swarm out and cover the tender branches in January and July for the two crops, respectively"

Hot weather crop superior.

Except in the case of Banyan.

Method of Propagation.

194 *Cultivation of Lac*—"It is during these months that it is possible to extend the area under Lac by artificial means. Small branches, covered with the incrustation are cut off and transferred to tender and succulent branches of other trees, in perhaps a totally different locality where Lac does not exist. In making the transfer, care has to be taken to place the cut off branches, bearing the incrustation, on the crowns of the tree intended to bear Lac, in order that as soon as the young brood swarm out they may [illegible] young and tender shoots to attach themselves to and may not all drop off on to the ground."

"In consequence [illegible]
in order to secure a [illegible]
of the incrustation [illegible]
is gathered, which was the case this year (1896)."

195. *Amount of Lac collected.*—"In the forests north [illegible] abad, each *babul* tree, it is computed, yields 7 to 15 [illegible]

C. [illegible]

CULTIVATION IN SIND.

on which the insect is found are of all sizes, varying from 1 to 6 or 8 feet in girth; but the insects confine themselves to the young and tender branches only of the trees. One can generally tell a Lac-bearing tract, because of the ground underneath each tree being strewn with cut-away branches, the Lac from which has been removed."

Relative yield of trees.

"[illegible] per tr [illegible] same [illegible] a tract about 20 miles north of Hyderabad, that Lac is seen on *tamarisk*"

Mr. Ryan then continues:—

No Pests.

196 *Injuries to Lac.*—"Fortunately, there are no insects in Sind which attack and destroy the Lac, as in other parts of India: the only injury to which it is exposed being climatic."

Favourable climatic conditions.

"If the rainfall is above the average, as in 1894 (*viz*, 10 26 inches in Hyderabad), and if floods in the Indus at the same time are *very* heavy, the excessive moisture in the soil and atmosphere brought about by these conditions affect the crop somewhat injuriously. A moderately moist season seems the most favourable for the propagation of the insect But conditions are so very unsettled, owing to the vagaries of the river caused by the present embankment system, that *no seasons scarcely are now alike. A contractor, who makes a large* profit in one year and who pays Government a better price for the next season's crop in expectation of another good crop, probably loses a large quantity of his preceding profits by a failure of the subsequent crop."

Profit.

197. *Will Lac Cultivation Pay.*—"This is not a difficult question to answer, for knowing the area actually covered by Lac and having the value realised from the farm annually, it becomes a simple arithmetical calculation. The area under Lac in the forests of the Hyderabad Division is estimated at 2,000 acres, and the value realised in 1895-96 is R7,560, which gives a net return of R3-12-0 per acre, or more than timber and firewood or cultivation"

"It would be advisable under the circumstances to cultivate Lac, and to set apart a certain area in each forest for maintaining an annual supply, and when it is found that the firewood and timber demand can be fairly met, the area under Lac might further be augmented."

Injury to Trees little *appreciable* in Sind.

198 "In the Jerruck Division the Lac-bearing area has been excluded from the working plan, and the same arrangement might be adopted for Hyderabad as well as forests in the Thar and Parkar District It is a mistake to suppose that the depredations of the insect in Sind damage the tree on which it subsists to any appreciable extent. This would be the case probably in a region where the rainfall was moderate, and where forest growth owed its existence to rain; all or a very [illegible] would soon be extracted by the [illegible] es in such localities, and in time [illegible] .n Sind, however, there is so much

moisture in the sub-soil, in the riverain reserves especially, that the *babul*, in spite of the tax which it has to pay in the shape of extraction of sap, and constant lopping of small branches, does not seem to be much injuriously affected. Most of the Lac-bearing trees are useless for timber, but they are nevertheless very huge, being 6 to 8 feet in girth with a splendid leaf canopy. There are forests in the Hyderabad District which have been yielding large supplies of Lac for the past 28 years and more without any apparent injury to them." CULTIVATION IN SIND.

Madras, Mysore and Coorg.

199. Lac is comparatively little produced in South India* and the industry of ornamentation with that product is but imperfectly under stood, except in one or two isolated localities. One of the earliest and to this day perhaps the most complete account of lac in this Presidency is that written by Dr. Buchanan-Hamilton a hundred years ago. The following passage may, therefore, be reproduced :— CULTIVATION IN MYSORE AND COORG.

Passages taken from " A Journey from Madras through the countries of Mysore, Canara and Malabar, by Francis Buchanan, Esq., M.D.," (***Buchanan-Hamilton***), ***Volume I, page 238, July 17th, 1800.*** Buchanan-Hamilton's account in A.D 1800.

200. " The people who manage the Lac insect, in the hills near *Nandidurga*, are of the caste called *Woddaru*; and for the exclusive use of the trees they pay a rent to Government. The tree on which the insect feeds is the *Jala*, which is nearly related to the *Saul* of Bengal, or the *Shorea* of Gaertner, and perhaps the Vatica chinensis of *Linnaeus* † All the trees that I saw here were small, not exceeding eight or ten feet in height; and their growth was kept down by the insect and its managers; for this size answers best. The tree, left to itself, grows to a large size and is good timber. For feeding the insect, it thrives very well in a dry barren soil; and it is not planted, but allowed to spring up spontaneously as nature directs. It is often choked by other trees, and destroyed by bamboos, which, by rubbing one against another, in this arid region, frequently take fire, and lay waste the neighbouring woods. By removing all other trees from the places where the *Jala* naturally grows, and perhaps by planting a few trees on some other hills, and protecting them from being choked as they gradually propagate themselves, the Lac insect might be raised to any extent on lands now totally useless, and never capable of being rendered

* Madras Manual of Administration, Volume I., 1885, page 314.
† This is Shorea Talura, *Roxb.*, which Mr. J. Cameron in his " Forest Trees of Mysore and Coorg " calls The Lac Tree or *Jalari*.—G. WATT.

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arable. In *Kartika*, or from about the middle of October to the middle of November, the Lac is ripe. At that time it surrounds almost every small branch of the trees, and destroys almost every leaf. The branches intended for sale are then cut off, spread out on mats, and dried in the shade. A tree or two that are fullest of the insects, are preserved to propagate the breed; and of these a small branch is tied to every tree in the month *Chaitra*, or from about the middle of March to the middle of April; at which time the trees again shoot out young branches and leaves. The Lac dried on the sticks is sold to the merchants of Balahari, Gutti, Bangalore, etc ; and according to the quantity raised, and to the demand varies in price, from 5 to 20 *Fanams a maund.* This is what is called *stick-lac.* In my account of Bangalore, I have given the process for dyeing with the substance, which, after the dye has been extracted, is formed into *seed* and *shell-lac.*"

201. The account given in the Gazetteer of Mysore and Coorg (*published 1877, page 164*) is an abbreviated version of Dr. Buchanan-Hamilton's paper and need not, therefore, be given here. But Mr. J. Cameron in his *Forest Trees of Mysore and Coorg* (*published 1894*) furnishes interesting particulars which may be regarded as bringing our knowledge of the lac production and trade down to a recent date. Mr. Cameron's remarks will be found under Shorea Talura, page 22, as follows.—

J. Cameron's remarks on Lac in Mysore.

202. "The Lac tree of Mysore confined to the deciduous tracts of the maidan. Abundant in the Anekal, Closepet, and Nundydroog Taluks, where the propagation of lac has been actively taken up by the Forest Department. In the first named Taluk, Mr. Bapu Rao, the Assistant Conservator of Forests, Bangalore District, is extending the propagation of both the tree and the insect very rapidly. Lac

Burma.

CULTIVATION IN BURMA.

203. In the introductory chapter (paragraph 2) it will be seen that a quotation has been given from John Huyghen van Linschoten's account of his explorations in the East (1596 A.D.) in which a reference occurs to the lac obtained from Burma. "The men of Pegu," he says, "(where the best is found, and most trafiqued withall) doe call it Treck,* and deale much therewith by carrying it into

* Is the word *Treck* here given the same as the modern Burmese name Cheik? —*G. Watt.*

CULTIVATION IN BURMA.

the Island of Sumatra." Balfour and other writers of half a century ago refer in special terms of commendation to the lac of the Shan States and of Siam It is thus curious that on passing down to modern times practically nothing of a definite nature is known of the lac of Burma. In passing I would remind the reader that it is necessary to be careful to distinguish lac from lacquer when speaking of Burma. The art of producing the latter has been carried to a great state of perfection in that province, but as the chief ingredient in lacquer is a vegetable oleo-resin obtained from Melanorrhœa usitata—the *thissi*—it is essentially a different art from that where the animal resin lac—*Cheik*—is employed. That Linschoten had not made this mistake is evident from his careful description of the incrustation on the trees—a substance which he adds is purified, melted and coloured as desired before use. It would thus almost seem as if the lac trade of Pegu some 300 years ago had been very much more valuable to the province than it is at the present time.

Lacquer and lac must not be confused.

204. With these introductory observations the course followed in dealing with other provinces' may now be pursued in the case of Burma, *viz.*, to give a selection of passages of an instructive nature from the chief books and official correspondence available .—

Passages taken from the revised edition (by Theobald) *of Mason's Burma, its People and Productions, Vol. I., page 37.*

Account in Mason's Burma.

205. "The lac insect is the most important member of this family. The male has two wings, and flies freely; but the female is apterous and parasitical (so to say) at all ages. The body is a mass of red-coloured paste, which is simply the lac-dye of commerce, and from the sides of her body exudes a resin in such quantities as gradually to encase her in a sort of cell; this resin is the 'shell-lac' of commerce. The crude lac, as brought to market, consists of the twigs whereon the resinous cells are attached, in which the female lac insects are contained. The whole mass is pounded up and steeped in water, which dissolves out the coloured matter formed of the insect's body. This is subsequently precipitated and formed into cakes, after which the refuse is heated, and the resin melted out. This process is conducted in canvas bags, which are subjected to pressure, and the pure resin as it exudes is scraped off in flakes which are termed 'shell-lac' being faintly orange-tinged. Dr. Mason says—"The Karens think the lac is produced by an ant, and call it the lac ant." The insect is parasitical on several species of trees

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as **Ficus religiosa** and other figs, **Butea frondosa**, **Zizyphus Jujuba**, etc., and is sometimes so crowded on the stems that they are seen incrusted, as it were, with pipe-like mass half an inch in diameter or more, made up of the closely-packed cells of the 'lac insect.' The finest 'lac' comes from Siam and the Shan States *via* Rangoon, and much is also collected in Assam and some parts of Bengal"

Mason specially states in his original work that "lac is not formed extensively in the British Provinces of Burma though very abundant in the Shan States adjoining."

Extract from the British Burma Gazetteer, Vol. I., 1880, page 415.

Trial of lac.

206. "*Lac.*—Though lac appears amongst the exportation from the province, and in no small quantities (1,335 cwt in 1877-78), yet by far the greater portion of this is imported from Burma and the Shan States. In 1874 the Forest Department commenced the cultivation and imported insects from the north, and in 1876 the lac nurseries at Ma ga-ree near Rangoon were formally declared to have been successful, but the success was short-lived The principal market is Calcutta."

Copy of letter, dated the 26th June 1894, from the Conservator of Forests, Western Circle, Burma, to the Inspector General of Forests.

207. "With reference to your demi-official Circular No. 1, dated 3rd January 1894, on the subject of lac, I have now received answers from my Divisional Officers to whom reference was made on the subject, but they all say that so far practically nothing is done in Lac in this Circle.

Price.

"The only people who have been in any way connected with this industry are some Chins in Laungshe township, Yaw Division, and 600 viss (of 3·65 lbs.) or about 19½ cwt. have been brought out this year, which sold for R55 per 100 viss (about R17 per cwt.) at Sinbyngym and Minbu "

Copy of letter No. 1677-3E-3, dated the 26th September 1896, from Mr. A. Smythies, B.A., *Officiating Conservator of Forests, Western Circle, Upper Burma, Mandalay, to the Inspector General of Forests.*

208. "With reference to your No. 2213—170, dated 20th July 1896, on the subject of lac, I have the honour to inform you that a

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few more particulars can be added to the demi-official letter, dated the 26th June 1894, but nothing of any real importance.

"The Forest Officer in the Upper Chindwin writes as follows:—

"The only lac industry that I have heard of in this Division is that in the Pinbon Circle, Banmauk Sub-Division of the Katha District.

Destruction of Trees.

"The forest from which the lac is brought is at the head waters of the Chaungyi Chaung which rises between the Kalat and Saitepha Hills; it is a stretch consisting of *Ingyin Tamalan* (Dalbergia Oliveri), *Taungthabye* and *Thabyegyi* (Eugenia sp.) trees mixed with Bamboos. The hills on which the lac insect is found are known as the Thandaung and Pedaingdaung. Every year in the months of Thadingyut, Tazaungmon and Nadaw the villagers of the Pinbon Circle proceed into the forest to collect the lac, felling trees and breaking off branches to get at it, the usual outturn is from 100 to 300 viss, but every 4 or 5 years the lac insect swarms and the outturn rises to about 2,000 viss. The lac is brought to Pinbon and sold to traders at the rate of 25 per 100 viss, delivered free at Hmegon on the Maze about 12 daings from Pinbon. The villagers pay duly at Pinbon to the Mausi Forester 12½ per cent *ad valorem*.

Price.

"A little of this lac is sometimes brought into Tammu *viâ* the Chindwin where it is sold for dyeing cloth.

Supply.

"The Forest Officer in the Yaw Division reports that about 1,000 viss (1 viss=3·65 lbs.) of lac was brought to Monywa during the year where it is sold for R25 per 100 viss; the middleman's profit is about R45 per 1,000 viss; the lac is collected from the end of September to the end of February, and it is found on Shorea obtusa and Shorea siamensis."

Extract from the Diary of* Mr R. M. Kavanagh, *Extra Assistant Conservator of Forests, for the week ending 30th February 1897, forwarded by the Officiating Conservator of Forests, Western Circle, Upper Burma, Mandalay.

Lac in Burma ruinously worked.

209 "The Thandung range has forests of a similar nature with a little teak here and there, and wherever *Ingyin* (Dipterocarpus tuberculatus) forests appear the lac insect propagates itself.

"The present mode of extraction is in my opinion ruinous, for the custom is as follows:—

"The villagers of Pembone, Shehhgih Tit-tonc, Tache, when they hear that lac is more or less plentiful, up they come and cut off branches, leaves, etc., and take all they can get, so that after they have left there is little or nothing remaining; whatever has been left by chance takes fully four years to repropagate itself, so that Government only gets revenue to any extent, once in four years; were this area reserved and the insect propagated artificially as well as naturally and the area

divided into block by block under a fixed rotation, Government would get a steady annual income."

CULTIVATION IN BURMA (Eastern Circle).

Copy of letter No. 707-47 A., dated the 28th June 1894, from the Officiating Conservator of Forests, Eastern Circle, Upper Burma, to the Inspector General of Forests to the Government of India.

210. "With reference to your demi-official Circular No 1, dated 3rd January 1894, I have the honour to report that lac is said to be largely exported from Western Karenni. The Deputy Conservator of Forests, Southern Shan States, has not been able to visit that part of the country this year, so is not prepared at present to give any detailed information in regard to the lac industry there.

"The only other tract of country where lac is reported to be common is the Pyinulwin Sub-Division of the Mandalay District, and the adjoining plateau of Thowza and Kalagwe in Hsibaw State.

Decrease of export.

"From this tract it is reported about 70,000 pounds were exported through Maymyo in 1890, and the quantity has steadily decreased to about 60,000 pounds, the quantity exported last year.

Host plants.

"In this tract it is collected chiefly from the smooth leaved species of **Ficus**, such as **F. religiosa**, **F. Rumphii**, etc., from the [illegible] (**Dalbergia** sp.) [illegible] l, though [illegible] d R9 to R10 in Mandalay.

"No attempt is made to foster its propagation and the collection is carried on in a haphazard way. In the rains, when the crops have been sown and there is nothing particular doing in the taungyas, the men go out to collect. Only a small number of persons are engaged in the business. In a village of 10 houses not perhaps more than 1 to 2 men. They say it does not pay them to go in for the work regularly, and that they merely collect it to supplement the returns from, their taungyas. Near Thibaw Mr. Copeland saw a good many **Ficus** trees on the roadside with lac, which apparently no one took the trouble to collect.

"It will be seen that the information received so far goes to show that there is no great field for extending the trade in lac, as far as this Circle is concerned."

211. The most recent writer on Burma, *viz*., Mr. M. Ferrars, gives lac the name of *Chcik*, but he speaks of it as brought into the province by the Shan traders. He gives full particulars of the Burmese lacquer trade, but makes no mention of lac industries. From this circumstance it may be inferred that lac is very little understood in

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Burma though it is probable a highly lucrative trade might be organised in the product.

Revenue realized on lac from State Forests.

REVENUE FROM LAC IN STATE FORESTS OF BENGAL.

1. *Bengal.*—The statement given below shows the quantity of lac removed from the Reserve and protected forests in Bengal and the revenue realized thereon during the last five years recorded in the Conservator's office.

YEARS.	RESERVED FORESTS.		PROTECTED FORESTS.		TOTAL.	
	Quantity	Value.	Quantity.	Value.	Quantity.	Value.
	Mds.	R	Mds.	R	Mds.	R
1894-95 . .	97	170	7	11	104	181
1895 96 . .	164	256	200	125	364	381
1896 97 . .	156	331	...	...	156	331
1897-98 . .	282	341	95	60	377	401
1898-19 . .	58	100	166	110	224	210
TOTAL .	757	1,198	468	306	1,225	1,504

REVENUE FROM LAC IN STATE FORESTS OF ASSAM.

2. *Assam.*—Mr. J. A. McKee, the Conservator of Forests, believes that the lac exported from Assam is nearly all collected from cultivated crops of *Cajanus indicus* and gives the following statement showing the revenue realized from Government forests on lac-mahal during the five years 1894-95 to 1898-99 .—

YEAR.	Revenue from lac-mahal	Revenue by sale of lac.	REMARKS.
	R	R	
1894-95	54	...	* By sale of 20 seers.
1895-96	62	4*	
1896-97	17	..	
1897-98	...	...	
1898-99	...		
TOTAL .	133	4	

REVENUE FROM LAC IN STATE FORESTS OF OUDH CIRCLE.

3. *North-Western Provinces and Oudh, Oudh Circle*—The Conservator of Forests, Oudh Circle, reported that the revenue realized from lac in the several Divisions of his Circle for the years 1894-95

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to 1898-99, was as follows: 1894-95, R80, 1895-95, R25, and 1898-99, R295 making up a total of R400 only. There was no revenue realized in 1896-97 and 1897-98.

REVENUE FROM LAC IN STATE FORESTS OF BURMA.

4. *Burma.*—The two Upper Burma Circles and Pegu Circles, Lower Burma, furnished reports that the revenues realized from lac in the Circles are as follows:—

		1894-95	1895-96	1896-97	1897-98	1898-99	TOTAL.
		R	R	R	R	R	R
Upper Burma,	Northern Circle	318	757	516	355	207	2,153
	Southern Circle	263	334	292	188	8	1,085
Lower Burma,	Pegu Circle .	321	240	92	26	4	683
	TOTAL .	902	1,331	900	569	219	3,921

Full particulars of the revenue realized in the Northern and Southern Circles, Upper Burma, are given by the Conservators in the following statements:—

Upper Burma. (1) Northern Circle.

(1) Northern Circle, Upper Burma.

Year.	Division	Lac in viss.	Revenue.	REMARKS.
			R	
1894-95	Bhamo . . .	3,818	286	Actual quantity collected at R7-8 per viss. 16 Licenses, estimated at 100 viss per license at R2
	Mu . . .	1,600	32	
	TOTAL .	5,418	318	
1895-96	Bhamo . . .	8,771	658	Actual quantity collected at R7-8 per 100 viss 2 Licenses estimated at 100 viss per license. 41 Licenses estimated at 100 viss per license. Actual quantity collected at R12-8 per 100 viss.
	Katha . . .	200	4	
	Mu . . .	4,100	82	
	Upper Chindwin .	104	13	
	TOTAL .	13,175	757	
1896-97	Bhamo . . .	6,744	506	Actual quantity collected. 1 License estimated at 100 viss. 4 Licenses estimated at 100 viss a license.
	Katha . . .	100	2	
	Mu . . .	400	8	
	TOTAL .	7,244	516	
1897-98 .	Bhamo . . .	4,745	355	Actual number of viss collected at R7-8 per 100 viss.
1898-99 .	Bhamo . . .	4,157	207	Actual number of viss collected at R5 per 100 viss.
	Total of 5 years .	34,739	2,153	

NOTE.—No licenses were issued to collect in reserved forests.

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REVENUE FROM LAC IN STATE FORESTS OF BURMA. (2) Southern Circle.

(2) Southern Circle, Upper Burma. (From July 1894 to June 1899.)

Forest Year.	Divisions.	No. of Licenses.	Revenue.	REMARKS.
			R	
From 1894 to 1895	Minbu . . .	14	28	* Includes 5 Licenses from reserves at 5 per license
	Yaw . . .	38*	91	
	Mandalay . .	72	144	
	TOTAL .	124	263	
From 1895 to 1896	Minbu . . .	10	20	
	Yaw . . .	59	118	
	Mandalay . .	98	196	
	TOTAL .	167	334	
From 1896 to 1897	Minbu . . .	.	...	
	Yaw . .	74	148	
	Mandalay . .	72	144	
	TOTAL .	146	292	
From 1897 to 1898.	Minbu . . .	..	...	
	Yaw . . .	74	148	
	Mandalay . .	20	40	
	TOTAL .	94	188	
From 1898 to 1899.	Minbu . . .	1	2	
	Yaw . . .	...	...	
	Mandalay . .	3	6	
	TOTAL .	4	8	
	GRAND TOTAL .	535*	1,085	*535 Licenses at 100 viss each=53,500 viss.

REMARKS.—In the Yaw and Minbu Divisions lac appears chiefly to come from hill forests not under the control of the Forest Department.

REVENUE FROM LAC IN STATE FORESTS OF THE CENTRAL PROVINCES.

5. *Central Provinces*.—(1) The Conservator of Forests, Southern Circle, reported that the total revenue realized from lac in the Government forests of his Circle during the last 5 years (1895-96 to 1899-1900) amounted to R21,351. He remarked that nearly half this amount was derived from the Raipur district alone, where the right to collect lac is leased out, and it would have been about R4,000 more had no remissions been made. Three Divisions, *viz.*, Bhandara, Nagpur-Wardha, and Sambalpur, showed no revenue at all from this source.

(2) From the Northern Circle R28,984 was realized during the past five years, *viz.*, 1894-95 to 1898-99. The amounts realized from

REVENUE FROM LAC IN STATE FORESTS OF THE CENTRAL PROVINCES.

the different Divisions during the period is given in the following statement:—

Year	Sold from the Government Forest of the								
	Mandalay Division	Jubbulpore Division.	Damoh Division	Saugor Division	Narsinghpore Division	Hoshangabad Division.	Betul Division.	Nimar Division.	Total for Northern Circles.
	R	R	R	R	R	R	R	R	R
1894-95 .	2,102	321	3,150	740	*Nil.*	532	1,283	*Nil.*	8,128
1895-96 .	1,145	1,823	2,200	517	275	1,079	1,283	78	8,401
1896-97 .	514	936	1,750	55	300	616	1,283	30	5,484
1897-98 .	432	414	717	33	8	419	440	*Nil.*	2,463
1898-99	1,625	956	767	162	70	385	541	2	4,508
Total .	5,819	4,450	8,584	1,507	653	3,031	4,830	110	28,984

Mr. E. E. Fernandez, the Officiating Conservator, also furnished figures showing the quantity and value of lac exported from the Central Provinces.—

Year.	Quantity and Value of Lac Exported from Central Provinces.					
	Stick Lac.		Shellac.		Total of both kinds.	
	Quantity in mds.	Value in R	Quantity in mds	Value in R	Quantity in mds	Value in R
1894-95 . .	76,125	19,69,736	1,127	57,477	77,252	20,27,213
1895-96 . .	79,843	20,36,000	1,591	87,903	81,434	21,23,903
1896-97 . .	64,174	10,58,869	2,499	1,30,885	66,673	11,89,754
1897-98 . .	48,686	6,63,347	3,443	1,48,910	52,129	8,12,257
1898-99 . .	38,064	4,80,556	1,649	61,835	39,713	5,42,391
Total .	306,892	62,08,508	10,309	4,87,010	317,201	66,95,518

In his report Mr. Fernandez made the following commentary which is very important:—

"(1) The value of the lac sold from the forests of the circle is almost exclusively the value of leases granted for the right of collection, so that it excludes cost of collection and

REVENUE FROM LAC IN STATE FORESTS OF THE CENTRAL PROVINCES.

transport to the railway and the profits of the middleman, whereas the figures given for export from the whole Province represent the prices on the railway. For comparison the former figures should be multiplied by at least 6.

(2) A still further allowance has to be made for a fair comparison. The Provincial figures include lac from the Rewah State *and Central Province Zamindaris (all of them specially* adapted by their climate for the production of lac on a large scale) and from Jagiri and Malguzari-lands. It would not be too much to say that under the most unfavourable circumstances the production from these sources will always be at least eight times that of the Government forest areas.

(3) In consequence of the free concessions granted on account of famine in 1896-97 and 1897-98 lac was almost clean stripped off from all our trees, so that even propagation was rendered extremely difficult. Hence the great falling off after 1895-96.

(4) The climate of Nimar is too dry and hot and that of the greater part of Saugor too cold to be favourable for the production of lac. These two districts contain more than one-fifth of the Government forest area of the Circle.

(5) When all is said and allowed for, the net value of the lac produced in the Government forests of the Circle and paid into the Government treasury should, under the attention which is now being given to the matter and provided meteorological conditions are normal (which has not been the case during the entire quinquennium), reach an average annual figure of R40,000.

(6) Lac is a product the theft of which is extremely easy to effect and as difficult to detect. Without such thefts our receipts from lac would be R60,000 instead of R40,000. It is, therefore, a matter for consideration whether Government should not levy a duty on lac produced elsewhere than in Government forests in order to recoup itself for the thefts committed by private land-owners and those who take on lease the production of private lands in order to be able to steal the lac from surrounding or adjoining Government forests."

REVENUE FROM LAC IN STATE FORESTS OF BERAR.

6. *Berar.*—The revenue realized on lac from the Government forests in 1894-95 was R1,924, in 1895-96 R1,288, in 1896-97, R866, in 1897-98, R386 and in 1898-99, R467 amounting to the total of R4,931 for the past five years.

REVENUE FROM LAC IN STATE FORESTS OF SIND.

7. *Sind.*—During the past five years the total revenue realized on lac from the forests in the Sind Circle was R34,641. The amounts realized from the three Divisions are shown below:—

YEAR	REVENUE REALIZED FROM LAC.			
	Hyderabad Division	Jerruck Division	Thar and Parkar Division.	TOTAL.
	R	R	R	R
1894-95	8,100	300	77	8,477
1895-96	7,350	367	370	8,087
1896-97	5,410	133	564	6,107
1897-98	8,190	...	645	8,835
1898-99	2,550	..	585	3,135
TOTAL	31,600	800	2,241	34,641

WHERE STATE FORESTS GET NO REVENUE FROM LAC.

Bombay, Madras and other Circles than those given above reported that no revenue was realized on lac from Government forests. From the reports abstracted above it will be noticed that during the past five years (1894-95 to 1898-99) the amounts realized are, from—

COMPLETE REVENUE

	R
(1) Bengal	1,504
(2) Assam	137
(3) Oudh	400
(4) Burma (Upper and Lower)	3,921
(5) Central Provinces	50,335
(6) Hyderabad Assigned Districts (Berar)	4,931
(7) Sind	34,641
TOTAL for 5 years	95,869

making a total of R95,869 realized from the Government Forests in India during the past five years. The average for a year calculated from above is R19,173-8, that is, Government get annually less than R20,000 out of an annual export of upwards of R1,40,000.

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MANUFACTURE OF LAC.

CHAPTER IV.

MANUFACTURE OF LAC.

NATIVE LAC FACTORY.

212. ***Native Lac Factory.***—So many persons have written on this subject that it may seem almost superfluous to attempt a new version of so old a story. The twigs with their incrustations of lac are brought from the forest to the factory. They are broken into short lengths—"stick-lac"—by hand or by machinery. This is next crushed either by the ordinary grain-mill, worked by one or two hands (*chakrī* or *jāntā*) or by rollers driven by steam power. The produce *is next sifted and assorted by various contrivances, the resulting* three substances:—(*a*) fragments of wood (used subsequently as fuel), (*b*) fine dust which consists of dirt and minute fragments of lac known as *khud* (a mixture sold to the makers of bangles, toys, etc.), and lastly granular lac known to the trade as "seed-lac."

WASHING SEED LAC.

213. *Washing Seed-lac.*—The next stage is to wash the seed-lac. This is done at the smaller native factories by placing the seed-lac within large circular stone troughs and covering it over with water. In this condition it is, as a rule, left for 24 hours. After having soaked to the desired extent a man or woman stands within each trough and (while holding on to a bamboo placed conveniently for that purpose) twists the body this way, and that while pressing every particle of lac, *against the roughly hewn surface of the stone trough. As a result the* so-called cells of the lac are broken up, the seed lac being reduced to a smaller and more uniform state of granulation. The water becomes at the same time of a deep purple claret colour. This is the lac dye or lake which has only to go through certain further stages of manipulation to be reduced to the well-known cakes—the form in which it appears, or, to be more correct, formerly appeared, in the market. In separating the washed lac from the dye a fine powder is obtained, which consists of dirt and minute particles of lac. This, when dried, is sold under the name of *Gaud*, and is like the *Khud* utilised by the manufacturers of lac bracelets.

Bleaching Seed lac.

214. *Bleaching Seed-lac.*—In some parts of the country, more specially in localities where regular lac factories do not exist but where the artisans prepare the lac required by themselves, a slightly different method of purifying seed-lac prevails. For example, a correspondent in Hoshiarpur in the Panjab sends a description of the process pursued in that district in which the lac is boiled in water

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containing *Sajji* (crude carbonate of soda) and *Suhoga* (borax). This interesting account has been given under Chapter VI. (page 325) and should be consulted.

So, again, from Hala in Hyderabad, Sind, information comes that "the lac, after it is scraped off the trees, gets dried in which state it is purchased and ground in a mill-stone. After which it is washed and purified with potash (*khar*) water. One-quarter of potash to four seers water will suffice to purify 10 seers of lac. It is then dried in the sun." Of Jaisalmer, it is said that the seed-lac is "put in the water of *sajji* and washed by the hand: sometimes it is washed by the water of *lodh* (Symplocos racemosa) and borax. The small pieces then become clean." From Jhallawar State it is reported "After the lac has been well rubbed up in water containing a little alum, it is strained through a cloth. Fresh water is then added and treated in the same way until the water ceases to become of a reddish colour."

The question has been raised recently by some of the larger dealers in shellac, whether the Native system of boiling the seed-lac in carbonate of soda did not much more effectually remove the colour and even bleach the lac than the simple trituration method already described. But a further point has also arisen, *viz.*, whether the shellac ultimately prepared from chemically washed and bleached lac is as good as that produced from the lac that has been washed in water only.

Loss of Profit in waste of Dye.

215. *Loss of Profit in Lac Dye.*—It might be almost said that the greatest calamity that has as yet overtaken the lac trade was the discovery of aniline dyes. From being the chief product, lake has declined until it is now of no value whatever. Not many years ago the dye might have been said to represent the manufacturers' profit. At the present day his greatest difficulty is to discover a convenient method of getting rid of this useless bye-product.

Usefulness of Machinery.

By machinery the washing of seed-lac may be more quickly and thoroughly accomplished than by the process briefly indicated as pursued where the lac factory consists of a constant water-supply, a few hand-mills, a stone trough or two and other simple appliances, along with chief labour. But it is perfectly wonderful what can be done with even the most elementary knowledge of mechanical contrivances. In fact it might be almost said that to the present day (in the lac industry) hand labour in one or two directions continues to produce

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results that the highest scientific and engineering skill have failed to accomplish. MANUFACTURE OF LAC.

216. With the washing of the seed-lac the industry was formerly referred to two distinct sections, *viz.*, (*a*) the manufacture of shellac (and all the other forms of the resinous product met with in trade), and (*b*) the preparation of the lake-dye. Although, as already briefly indicated, the latter no longer figures as a commercial article, there is still a small local consumption of the dye. It may, therefore, be convenient to discuss the further stages of manufacture under the sections indicated and to bring together under each of these a selection of the more useful and interesting passages from the published accounts and official correspondence available regarding each of these branches of the trade.

I.—SHELLAC, BUTTON LAC, ETC.

217. In a further passage it will be found that Mr D. Hooper has been good enough to furnish for this paper the results of his chemical investigations with lac. Although a knowledge of the chemical properties of this substance is essential to the full appreciation of the methods of manufacture, it may be convenient to discuss here the various stages of manufacture usually pursued. MANUFACTURE OF SHELLAC, BUTTON LAC.

After being washed the seed-lac is conveyed to specially prepared drying floors. It is there exposed to the atmosphere and light by which it is thoroughly dried and to some extent bleached.

218. *Mixture of Orpiment and Rosin.*—According to the particular class of manufacture desired lac is now very often mixed with either or both of the following substances, *viz*, orpiment (or yellow arsenic) and resin. The latter is obtained for the most part from Canada (pine rosin). The former is procured in India and apparently serves mainly (if not entirely) a mechanical purpose. It makes the lac opaque, but at the same time imparts to it a rich pale-straw colour—properties characteristic of all the finer grades of hand-made shellac. Arsenic is not, however, employed in the manufacture of Garnet, Button and the other grades where paleness of colour is not so much demanded. The rosin seems to act the part of lowering the melting point, in many industries a distinct necessity. Its value, therefore, is fully recognised and a certain admixture is not only admissible by the rules of the trade, but few of the shellacs that are regularly Mixture of Orpiment and Rosin.

MANUFACTURE OF SHELL-LAC, BUTTON LAC.

exported can be said to be entirely free from rosin. Since, however, the price of lac fluctuates very greatly and is in any case much higher than rosin, the temptation is ever present to raise the percentage of rosin mixed with lac. This circumstance may be accepted as one of those that most readily determines the quality and value of lac. During seasons of high prices, the admixture of rosin is often raised until it passes from the condition of permissible admixture to what might be called criminal adulteration. Samples of lac have been examined that contained from 50 to 70 per cent. of Canadian resin instead of the normal 2 to 5 per cent.

The orpiment is ground to a fine powder by the *janta* (double-handed stone-mill) and it is a striking feature of the lac industry to watch this operation Women, for the most part grind the orpiment, and as often as not they have children alongside of them playing with the blocks of yellow stone or perchance amused by lending their little hands to assist in throwing the stones into the mill The whole party are literally yellow with the powder produced, and yet it is commonly asserted that no evil consequences are known to be occasioned by this dangerous looking occupation.

219. Referring to the practice of mixing arsenic with lac prior to its being melted into shellac, Mr. E. A. Short of Angelo Brothers recently enquired: "I am anxious to know if there is any substitute for arsenic fusible at or below the temperature corresponding to that of about 35 lbs. of steam power. By the hand method the arsenic fuses into the lac owing to the high temperature of an open fire. We want some substance, giving the same effect of yellow colour and opaqueness, but fusible under the above steam-heating."

Unfortunately the researches conducted at the laboratory connected with the Office of Reporter on Economic Products have as yet failed to discover a substance that could answer the part of orpiment in the shellac trade

Process of Melting.

220. *Process of Melting.*—After the lac has been carefully mixed with the desired quantity of arsenic or quantities of arsenic and resin, the mixture is packed within very long narrow cloth bags. These are about 2 inches in diameter and perhaps 10 or 20 feet in length. For one class of lac American drill is employed, for another a special cloth made at the Cawnpore Mills, and for a third two bags are necessary one inside the other. After the bags have been charged

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MANUFACTURE OF SHELL-LAC. BUTTON LAC.

with the lac they are conveyed to the furnace or heating room. For the purpose of melting the lac, long shallow fires of coke or charcoal are employed. These are open in front and are perhaps three feet long, a foot deep, and have an arching masonry roof that completely protects the operator's face from the glare of the fire that he has to keep at a uniform temperature and glow. The bag charged with lac is now drawn along the face of the fire, its weight being carried by bamboo uprights at intervals, while at the far end a short stick has been tied at right angles to the length of the bag. The foreman operator sits on a little raised mud platform to the immediate left of the fire and holds in his left hand the end of the bag. At the other extremity, one of his mates seizes the cross stick and commences to slowly but firmly twist the bag. The heat melts the lac and the squeezing of the bag causes a continuous oozing from the portion exposed to the fire. Every now and again the foreman operator gives his end of the bag a reverse twist which causes the portion from which lac has been expressed to coil round like a rope. Steadily the bag is drawn forward as portion after portion is exhausted. With the right hand the operator wields at intervals three weapons—one a long iron poker which has a wooden handle and a crook-like bend on the further end. With this the fire is every now and again trimmed. Alongside of him is placed an earthen jar full of water. From this, by means of a wooden spoon, he every now and again sprinkles the floor in front of the fire which is so placed as to be a couple of inches below the bottom level of the fire. Over this floor is sometimes put the smooth leaf-sheaths of the plantain stem, at other times the succulent leaves of the American aloe or more frequently still (especially in the more go-ahead factories), polished tiles have been placed. The third weapon used by the master operator is an iron scraper, also furnished with a wooden handle With this the molten lac, as it oozes from the bag, is scrapped off a d let fall on the damp flooring. If not sufficiently cooked, it is again picked up and placed on the bag to be once more melted At first sight it seems as if any person could assume the rôle of foreman operator to the gang of four or five who constitute the working party at each furnace. But a little more study reveals the fact that there is great skill in knowing when the lac has been cooked (as it is expressed) to the desired extent necessary for the particular manufacture in hand.

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MANUFACTURE OF SHELL LAC BUTTON LAC.

Allotropic change.

221. *Allotropic Change.*—There would almost seem as if the repeated falling on a damp surface and re-melting that ensues had something to say to the peculiar merit of the hand as compared with the machine-made shellac. One might imagine some allotropic or physical change in the lac thus brought about since the skilled operator can tell at once that the lump of lac he hands over to his assistant will possess or will not possess the elasticity necessary to admit of its being stretched to a fineness of tissue paper. Chemistry has so far failed, however, to reveal any direct change as brought about by this dropping of the molten mass on to a damp floor and again and again repeating the process, until the required degree of cooking has been attained.

Stretching Shellac.

222. *Stretching Shellac.*—The next stage in the manufacture of lac is the various methods pursued to stretch the lac into large sheets of the fineness required. In the more primitive factories this is done by placing a lump of molten lac on a plantain stem held at an angle of 60° to the floor. By means of a ribbon obtained from the cocoa-nut palm leaf or from the American aloe the mass of soft lac is pulled out along the plantain stem the operator holding the ribbon firmly in his hands and carrying it deftly along so that the lump of lac is flattened out to a large sheet of uniform thickness throughout. Recently the plantain stem has been substituted by porcelain tubes filled with hot water and more recently still metal pipes of polished zinc. After the lac has been stretched to the utmost possible on the inclined tube it is clipped off at top and bottom and given to a third workman. It is carried off to a little distance in front of the fire where a mat has been placed for that purpose. Seizing the sheet between the toes, hands and teeth this operator stretches it to fully double its former size and then laying it down on the mat (where it looks like a hide stretched to dry) carries it farther and farther from the fire so as to allow each succeeding sheet to cool slowly. The molten lac when handed to this workman is so hot that it would burn the hand dangerously of any person not accustomed to handle it. The practised workman not only holds it firmly and stretches it in all directions in the manner described, but he stands the while within a few feet of the furnace so as to afford the necessary additional temperature to facilitate the stretching.

Forms.

223. *Forms of Manufactured Lac.*—The next stage is to have the sheets minutely examined and all dark coloured or dirt impreg-

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nated portions broken out and the balance assorted according to purity and shade of colour—in other words into recognised trade qualities of shellac. The various qualities of shellac are known as "Fine Orange D. C.," "Livery," "Native Leaf," etc. A peculiarity of lac may be here mentioned, namely, that no portion can be regarded as useless. The parings and fragments at every stage of the shellac manufacture are thrown back once more on the floor of the melting furnace and are again melted and made into fresh sheets. But at every stage portions are found that are unsuited for the manufacture of shellac but which are nevertheless quite suited for other industries and find ready enough sale as special forms. For example, certain qualities of lac on being squeezed from the melting bag are allowed to drop on the plantain leaf-sheaths or other smooth surfaces, in circular patches an inch and half in diameter, in order to form the "button-lac" of commerce. Only the finer qualities of seed-lac are, as a rule, made into shellac owing to their paler colour. The more highly coloured lacs are made into thick dark-red sheets, known as "garnet-lac." MANUFACTURE OF SHELL LAC, BUTTON LAC.

224. *Cleaning the Melting Bags.*—After the melting has been completed the bags are boiled in alkali in order to remove the residuary matter, known as *kiri* or *phog*. From this, two qualities of inferior lac are still procurable, namely, that which is removable from the texture of the bag itself and the other the contents of the bag These two substances are made into thick circular slabs, perhaps six inches in diameter and an inch in thickness. In this form they are sold to the makers of sealing wax bangles and other such articles. The bags are finally washed, repaired and returned to be used again and again until no longer serviceable. Cleaning the Melting Bags.

225. *Method of Selling Lac.*—By way of concluding this brief sketch of an ordinary native lac factory it may be interesting to mention the manner in which lac transactions are often conducted. The traders sit two and two, the one facing the other. They join hands and place a cloth over the hands, the bargaining being done by a system of symbols in pressing the fingers. Method of Selling Lac.

226. The following passages may be now given from some of the standard works on this subject with a view to amplify what has been stated and to make known the slight local modifications of the system that here and there prevail.

MANUFACTURE OF SHELL LAC BUTTON LAC.

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Forms

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by the hand into rough cakes called *kiris* which are sold for local use at ₨4 per maund.

MANUFACTURE OF SHELL-LAC BUTTON LAC, ETC.

"A special variety of shell-lac, very pure in quality but rather darker than the favourite shell-lac of commerce, has usually been produced by the Ranchee Lac Company. This variety is known to the market under the H. S. L mark, and the Company have recently been engaged on a contract to supply it at the rate of ₨48 per maund."

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228. *Extract from Bulletin No. 6 of the Agricultural Department of Assam.—A Note on the Lac Industry of Assam, by B. C. Basu, Esq., Assistant Director.*

"Shell and button lac is manufactured in small quantities in Sibsagar and at Mr. Mackenzie's Factory, Rajpur Estate, Cachar. The process of manufacture is the same as followed elsewhere The crude lac is first crushed and sifted to free it from woody matter It is then subjected to a long course of alternate washing and drying, until the resin is thoroughly free from colouring matter. The lac, called in this stage *seed-lac*, is then put into a long cloth bag which is held and slowly turned over a charcoal fire. When the resin inside the bag has melted, it is squeezed out by twisting the bag, and is brushed off by drawing it over the smooth surface of a piece of plantain bark. Mr. Mackenzie mixes a small proportion of rosin with the crude lac. In Sibsagar, the lac is washed in alkaline water (*khárpáni*) prepared from the ashes of the plantain tree at one stage of the long course of washing to which it is subjected. Occasionally the residue left in the process of dyeing with crude lac is melted and cast into cakes which are sold along with stick-lac, but they still retain some dyeing matter

"Another preparation of lac used in Assam is what has been called 'boiled lac' in some of the district reports. In the Assam Valley, it is known as '*Bhiri Laha*.' It is prepared by boiling stick-lac for some hours, until it becomes soft, and then pressing the softened mass into cakes It, of course, retains the whole of the dye"

229. *Improved Methods with Steam Power.*—When steam power is used the process differs from the every day native factory, mainly in magnitude and rapidity of action. The principles involved and the results attained are almost precisely identical.

Improved Methods with Steam Power.

Crude stick-lac is passed between rollers worked by steam. There are usually three sets of these rollers in pairs, an upper and under roller with a sieve attached. The stick-lac passes from a feeder and is crushed by the rollers into "seed-lac" and at the same time separated from the wood by sieves. The broken lac falls from the sieves into a series of small troughs arranged on an endless chain and is projected, as the chain moves, into a heap on the floor.

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MANUFACTURE OF SHELL-LAC, BUTTON LAC, ETC.

The twigs and fragments of wood are thrown off on to a platform on the other side.

The lac is now placed in a horizontal cylinder within which revolves a bar carrying arms, throughout its length. Water is supplied and while the action of the arms breaks the lac into very small pieces, it separates the colouring matter or lac-dye.

230. The washed lac is now thoroughly melted in bags passing through metal jacketed tubes heated by steam, and thence conducted into open shallow troughs, also heated by steam, where the melting continues and the molten mass is thoroughly stirred. When the resin has been thus sufficiently "cooked" it is passed over carefully heated zinc rollers, somewhat similar to those used in making paper, and the sheets of shellac, garnet-lac, etc., by an ingenius contrivance, are caught on bamboo poles and conveyed to a drying room, and ultimately packed in cases for export.

Position of the Lac Trade.

231. ***Position of the Lac Trade.***—Having thus briefly narrated some of the more striking peculiarities of lac factories, it may be useful to give particulars of the extent of the industry of lac-making.

Mr. J. E. O'Conor. (*Financial and Commercial Statistics of British India, 1900*) furnishes the following returns:—

Number of Lac Factories.

	1889	1890.	1891.	1892	1893	1894	1895	1896	1897.	1898.
Bengal	34	34	39	34	77	84	99	92	100	95
North-Western Provinces and Oudh . . .	29	25	37	25	24	38	39	41	41	44
TOTAL .	63	59	76	59	101	122	138	133	141	139
	PERSONS EMPLOYED.									
Permanent . . .	2,030	2,684	3,002	2,632	3,304	3,814	3,128	3,533	4,073	...
Working season only .	805	1,347	1,555	1,565	1,565	1,205	595	553	715	...
TOTAL .	2,835	4,031	4,557	4,197	4,869	5,019	3,723	4,086	4,788	7,822
	VALUE OF PRODUCE.									
TOTAL R .	167,433	185,740	228,398	211,977	314,963	605,175	389,602	720,422	641,749	494,225

232. It will thus be seen that the lac factories of India, of which returns are available, are located in two provinces, namely, Bengal

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and the North-West Provinces. Further, that a very great expansion has recently taken place in the Bengal interest in this industry. The value of the produce has been returned in tens of rupees and the average for the past three years shows an industry of close on half a million pounds sterling. Although there are no returns of the factories in other provinces of India, it is well known that lac is used up locally to a large extent. Accordingly it might be safe to assume that the statistical returns furnished above very possibly express little more than half the value of the total trade.

II. Lac Dye.

MANUFACTURE OF LAC-DYE.

233. Dr. U. C. Dutt, in his *Materia Medica of the Hindus* (*page 276*), tells us that "the fluid lac-dye obtained by dissolving the crushed stick-lac in water is called *Alakta*. It is used in colouring silk Cotton coloured with this dye and pressed into flat circular pieces is sold in the bazars under the name of *Alta* and is used in painting the hands and feet of Hindu females." Dutt's work was compiled mainly from the Sanskrit authors and may be viewed therefore as expressive of the antiquity of the knowledge in this tinctorial agent. It was due to the desire to discover a cheap substitute for Cochineal as a dye for the uniforms of soldiers that attention of Europe was first drawn to this substance. Although then freely recognised as by no means affording a colour comparable in brilliancy with Cochineal, lac-dye was recognised as being a good serviceable substitute that at least possessed the advantages of cheapness and durability—it is not affected so readily by human perspiration. But when the aniline dyes were discovered a new state of affairs came into operation. Lac-dye, even as a bye-product, cannot compare in price with the coal-tar dyes, and hence where durability is no criterion, lac-dye fell into disuse, and where price is no consideration, Cochineal was naturally preferred. Between these two influences, therefore, lac-dye rapidly ceased to have a commercial position.

234. The process of manufacture of dye varied to some extent in the localities where it was produced according as destined for foreign or local consumption. Since some of the methods stand a chance of being forgotten, it may be desirable to place the more useful particulars on record in this place against the time when a revival of the trade may be called for. It would, indeed, be contrary

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to all modern experience if no use could be found for a bye-product of such ease of production.

Bengal.

235 The following passage from an interesting account that appeared in the *Statistical Reporter* (*Vol. II, page 406*) expresses the system that was pursued about the year 1876 in Ranchee:—

"The process of extracting the dye is somewhat peculiar. A woman stands in each tub on the wet seed-lac, and, steadying herself against the wall with her hands, turns her body violently to the

inual state of fric-
At intervals the tub
the bottom, while

the dye rises to the surface and is skimmed off in shallow pans. This process is repeated at intervals, until the lac-dye has been completely extracted and the water poured into the tub shows no trace of colour. A full day's work in scouring out the dye is estimated to produce a maund and a quarter (102 lbs) of seed-lac from which the dye has been extracted For this an anna and a half is paid. The dye, which is taken up in the form of coloured water from the scouring-tubs, is strained through coarse cloth on a gently sloping platform with a raised edge. Fragments of seed-lac, wood, and dirt that may have been taken up with the water out of the tubs, remain in the straining cloths, and this refuse is subsequently dried and sifted and sold as *pank*, for R3 per maund The pure colouring matter, still held in solution by the water, runs slowly off the platform through a fine

descending ser

is covered with

water is poured in to precipitate the dye. By the next morning the dye has settled, and is ready to be run out into boxes lined with cotton cloth and with small holes in their sides. From these the dye is transferred to compressible frames containing strong iron plates, and reduced by screw press to solid sheets of dark purple dye about a quarter of an inch thick These are cut up into cakes and stored *until dry enough for packing.*"

Passage from J. E. O'Conor's *note on Lac Manufacture, etc.,* *(1876).*

236. A good account of the manufacture in accordance with the ordinary processes is given in the following extract from a paper by Mr H. A. Crichton, of Ranchee, which was published in the supplement to the *British Burma Gazette* for 11th April 1874:—"The

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grain is first placed under *dekis*, or triturated in some other manner and water is poured or flows over it at the time of trituration, the result being that the colouring matter passes from the grain, which remains of a golden colour, into the water.

"The grain is then dried and stored for making shell-lac. The dye containing water is run off into a vat and allowed to remain there till the dye is precipitated, looking like dark mud at the bottom of the vat. The surface water is then run off, and the precipitate removed from the vat. The water is first expressed by placing the precipitate in cloths and allowing the water to pass away through the cloth. Frames should be prepared, about 18 inches square, having compartments about 1½ inch square; the frames to be fitted with loose tops and bottoms, the whole susceptible of compression. When the muddy matter is tolerably consistent, the compartment should be filled with it and put into a screw press The water will then be expressed, and when the cake is firm, it may be thrown on a clean floor to dry thoroughly, and will be a cake of lac-dye and fit for the market."

Passages taken from* Dr. H M'Cann's, *Dyes and Tans of Bengal, pages 53—56, 1883, on the subject of Lac.

Dye preparation.

237. Space cannot be afforded to reproduce Dr. M'Cann's paper in full. Such passages as give local peculiarities only in the preparation of the dye are therefore given in the passages that follow.—

238. "*Preparation of the dye.*—The following are the methods employed by the native dyers of Bengal for preparing the dye from the crude stick-lac. These may be divided into three stages —(1) the separation of the resin from the wood round which it forms an incrustation; (2) the separation of the dye contained in this (lac-dye) from the resin (seed-lac), (3) the formation of the dye into solid cakes.

Separation of resin from wood.

"The first of these objects is obtained by pounding the stick-lac between stones, or grinding it in some way: the resin separates readily from the twigs, which are removed

Extraction of dye from the resin.

"The contained dye is then separated from the resin by pounding the resin into a finer powder and leaving it to soak in pots or troughs of water for periods varying from 6 to 24 hours Generally after the first trituration the powdered resin is left to soak by itself, but sometimes *it is rubbed continually under the water to ensure the* complete separation of the dye from the resin, and fresh water is added at intervals. When the dye and the resin are completely separated, the thick liquid containing the dye is strained off through a piece of coarse cloth, leaving the resin (shell-lac) behind.

Formation of dye into cakes.

239 "In order to obtain the dye in the form of solid cakes, the liquid thus obtained is simply left to settle in vats, at the bottom of which a thick sediment forms. Sometimes a little *lime-water* or *quicklime* is added to quicken the formation of this sediment, sometimes a series of vats, generally three, one above the other, are employed. The liquid is first run into the upper vat, where a sediment is soon formed; the liquid remaining is then run into the

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second vat, where another sediment forms more slowly; the liquid from this is then run into the lower vat, where the precipitation of all that remains of the lac-dye is ensured by adding a small quantity of *lime-water* (Birbhum, Manbhum).

240. "The thick sediment thus obtained is then placed in wooden boxes and pressed into the form of cakes. The wooden boxes are sometimes lined with cloth to absorb part of the moisture. The cakes are then dried by exposure to the air and cut into the required size. These cakes constitute the lac-dye of commerce. In some places the dye is made into small balls instead of cakes (Lohardaga).

Preparation of dye from crude stick lac.

241. "Frequently the dye when required is prepared directly from the crude stick-lack, and not from the cakes of dye. In Maldah the Collector reports that for this purpose the stick-lac is ground, and then left to soak in water for about six hours (or a whole night) in an earthen vessel: about 12 seers of water being used for about 10 seers of the powdered stick-lac. The quantity of water is given as two maunds in another account. The lac powder is then squeezed and rubbed with the hand and 4 or 5 tolas of *sajjimati* are thrown in whilst this is going on, and the whole is sometimes well mixed together by rubbing with the feet. It is then strained and the liquid placed in another earthen vessel and boiled; afterwards 15 tolas of the strained powder of the bark of the *lodh* tree (Symplocos racemosa, *Roxb.*) are mixed gradually with it, and it is left to stand for a day. The scum and froth are then skimmed off, and the liquid is strained through a cloth and is ready for use. The liquid dye thus obtained is called *bol.* Sometimes this liquid is further mixed with hot tamarind-water, prepared by mixing $2\frac{1}{2}$ or 3 seers of tamarind with 1 maund of water.

Used as a coasmetic.

242. "Lac-dye seems to be employed in various parts of Bengal by native women as a cosmetic [illegible] the palms of the hand or tips of [illegible] mehndi or henna (Lawsonia [illegible] employed for that purpose. To [illegible] stick-lac are bruised in water, and cakes made either of cotton (Murshidabad) or of the similar floss covering the seeds of the *mudar* (Calotropis gigantea) are steeped in the water, so that the fibres may attract the dye (Lohardaga). These are the cakes used as cosmetics either by wetting them and rubbing them on the hands and feet, or else by soaking them in water and applying the water to the skin. These cakes are called *alta* (Murshidabad).

European capital

[illegible] the manufacture [illegible] mention was [illegible] ories:—One in the Birbhum District, that of Messrs. Farquharson & Campbell, of [illegible]

Decline of lac-dye industry.

[illegible]

given to the preparation of the dye, as it was ceasing to be remunerative owing to the fact that cochineal was rapidly taking its place in Europe and aniline dyes in this country. The reports of the Collectors were nearly unanimous in stating that wherever aniline dyes
were kn[illegible]
The fall [illegible]
about R1 [illegible]
the simultaneous introduction of these cheaper mineral dyes."

MANUFACTURE OF LAC DYE IN BENGAL.

Extract from a Note by Mr. T. N. Mukharji *on a visit to a Calcutta Lac Factory.*

244. "The lac when broken is next steeped in water in a vat or
[illegible] 24 hours, after which, while still
[illegible] he feet or carefully rubbed with
[illegible] adhering to the lac-resin is
[illegible] prejudicial to the preparation of
[illegible] ie lac is steeped and washed
becomes impregnated with the red colouring matter. This water was *formerly boiled* * *and evaporated, in order to obtain the colouring* matter in a dry state, which was made into cakes and sold as 'lac-dye.' At present there is no demand for the lac-dye, and the coloured water is now thrown away, thus turning into a waste product, what was formerly a source of profit. In short, this is the principal cause of the decline of the trade in lac."

Assam.

Extract from Bulletin No. 6 of Department of Agriculture, Assam—A Note on the Lac Industries, B. C. Basu, *Assistant Director.*

MANUFACTURE OF LAC DYE IN ASSAM.

245. "The commercial product known as lac-dye is nowhere prepared now-a-days in Assam The dye can, however, be easily extracted from crude or boiled lac, and is in every day use in Assam for dyeing cloths and yarns The following description of the process of lac-dyeing, as practised in Assam, is reproduced from Mr. Duncan's Monograph on Dyes and Dyeing in Assam —

"Lac furnishes one of the dyes most commonly used in the province, both alone and with other ingredients Used alone, the process is as follows:—The lac is pounded to a very fine dust. It is then thoroughly washed in warm water by rubbing the particles in the hands. The water assumes a red tint, and when all the colour has been extracted from the dust, the decoction is very carefully strained so as to prevent any of the dust being left in the dyeing fluid. This is to prevent the lac substance, which is sticky, from afterwards adhering to the cloth or other article to be dyed The fluid so obtained is then boiled, and. when boiling, the cloth (or thread) is put in and allowed to remain until it assumes the required shade. The result is a red.

* No other writer in connection with the province of Bengal appears to mention boiling as necessary. (*Conf. with pp. 232 and 233*).—*G Watt.*

MANUFACTURE OF LAC-DYE IN ASSAM.

This process, which I watched in Jorhat, is typical of the simplest form of use of the insect without other ingredients for dyeing purposes.

246 "The articles usually coloured with lac-dye are cotton cloths and thread of every kind of material (cotton, silk, *muga* or *eri*). The use of the dye in the Assam Valley is confined to the Kacharis, Mikirs and other non-Hindu tribes. The Hindus have a natural aversion for dyes of animal origin"

MANUFACTURE OF LAC-DYE IN THE N.-W. PROVINCES AND OUDH.

North-West Provinces and Oudh.

Extract from the Gazetteer, Vol. XIV (1884), pp. 214-5.

247. "The process of preparing the 'stick-lac' of commerce for exportation is extremely simple; it consists merely in separating the lac from the stick, and dividing it into its component parts of colouring matter and resin. The stick-lac is first roughly ground up, and [illegible] luch the lac is formed) [illegible] ater which absorbs the [illegible], where the dye precipitates itself. The water is then drained off, and the dye put into presses and made into cakes in which form, when dry, it is exported. After the dye has been absorbed by the water, the residue, which is called 'seed-lac' is cleaned by sifting, filled into long cylindrical bags of cotton cloth (which are turned in front of charcoal furnaces until the lac melts), and then strained or forced through the pores of the cloth by twisting the bags. The lac so strained is stretched [illegible] to the requisite amount of thickness; it then [illegible] do. [illegible] of native houses, large and small The industry probably employs, directly or indirectly, not less than 4,000 people. 'The total capital employed in the manufacture is returned (1881-82) at over 25 lakhs of rupees, and the value of the annual outturn has been calculated to be R16,00,000. Almost four-fifths of the total capital employed is represented by the four factories which are in European or Armenian hands. The industry is said to be suffering severely from the fall in the price of lac-dye which has taken place in late years. (Report on the Railway-borne Traffic of the North-Western Provinces and Oudh for 1881-82, p. 40)."

Passages taken from Mr. Buck's *Dyes and Tans, 1878, pages 24 25.*

Preparation of the dye.

249. "Lac-dye is made from the watery infusion which remains after the trituration and washing of the stick-lac. This is evaporated*

* It will be recollected that Mr. T. N. Mukharji mentions boiling as practised in Bengal. (*Conf. with p. 291*) — *G. Watt*

to dryness and the residium made into cakes about 2 inches square and half an inch thick. **MANUFACTURE OF LAC-DYE.**

250. "In these provinces lac-dye is chiefly used in dyeing leather, silk and wool. The process followed will be described under the headings allotted to these industries. The dye is prepared for use by being boiled in water; in some places it is merely soaked in water with a little borax. The colours it produces are red, dark-brown, and red-brown." **Use of lac-dye.**

Central Provinces.

Passages taken from Mr. Russel's ***Monograph on Dyeing Industry of the Central Provinces for 1896, page 10.*** **MANUFACTURE OF LAC DYE IN THE CENTRAL PROVINCES.**

251. "Stick-lac is the only form used by the dyers of the Central Provinces. It is gathered by the jungle tribes who break off twigs and small branches on which incrustations have been formed and scrape them off the larger branches. They sell it, as it is gathered, to the Komtis or merchants, who sell it to the dyers. The price is stated to be about R10 per maund. The dyers place it on a board and pound it lightly with an iron rod in order to separate the wood and dirt from the lac incrustation. The lac is then boiled with *lodh* * bark and *datia khar* (carbonate of soda). For a seer of lac eight tolas each of *lodh* bark and *datia khar* are used, and these will be boiled in a gallon of water. After boiling for about two hours, it is taken off and allowed to stand for three days. A sediment has then formed, and the water is then strained off leaving this. The water is mixed with fermented tamarind juice and heated over a fire. When it is hot, the silk thread to be dyed is put into the mixture and boiled in it for about a quarter of an hour, when it becomes thoroughly impregnated with the dye. In Chhindwara to one seer of lac, 5 tolas of alum, 20 tolas of tamarind leaves and a tola of *lodh* bark are added These ingredients are boiled together in water and the thread is dipped into the mixture and taken [illegible] **Uses of dye.**

[illegible]

fourth of its weight in the dyeing process. The cloth [illegible] a seer of dyed silk costs R20. The silk-dyers state that [illegible] not use aniline dyes owing to their fleeting character, [illegible] naturally a more important point in the case of silk [illegible] fabrics owing to their greater value. The manufacture of [illegible] these provinces has been affected to a certain degree by the [illegible] of ready woven cloths from Benares. These are stated [illegible] but less durable, than the cloths made in the Centra[illegible] The silk-weavers say they make about R10 a month [illegible] In Mandla white wool is dyed with lac by the [illegible] ornament their blankets with a stripe or two of [illegible]

* Symplocos racemosa.

MANUFACTURE OF LAC-DYE IN THE PANJAB.

In Raipur the *Chamars* use it for colouring the fine leather from which the upper parts of shoes are made. The dyers say that lac is not suitable for dyeing cotton cloth."

Panjab.

Passages taken from Baden-Powell's Hand-book of the Economic Products of the Panjab, Vol. I., pages 193-194.

Lac-dye.

252. "This dye is obtained from lac by treating the crushed lac with water to dissolve the colouring matter; as before observed, it is [illegible] the lac [illegible] sect has escaped from its resinous envelope, the quantity of colouring matter obtainable is very small."

"The lac-dye of commerce is prepared by evaporating the coloured tincture to dryness, when the residue is formed into little cakes, two inches square and half an inch thick; these are of various qualities and are marked with different letters by which the quality is recognized."

CHAPTER V.

CHEMISTRY.

(By Mr. D. Hooper.)

CHEMISTRY.

253. *Lac.*—The chemical constituents of crude lac have been separated and investigated by various chemists during the past 70 or 80 years. Drs. John and von Undervorben were the first to experiment with this product, and their results, more as a curiosity at the present day than from any real value, have been quoted in all standard works. The latter investigator in 1828 found the crude or sticklac to contain the following ingredients:—

von Undervorben on the Composition of crude lac.

1. A resin soluble in alcohol and ether. 2. A resin soluble in alcohol, insoluble in either. 3. A resinous body, little soluble in cold alcohol. 4. A crystallisable resin. 5. Wax. 6. The fat of the insect consisting of oleic and stearic acids. 7. A brown extractive, the laccine of Dr. John. 8 A colouring matter.

254. In 1835 Nees von Esenbeck and Cl. Marquart obained from shellac four resins, wax and traces of a dyeing principle. The resins

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were distinguished by their solubility in alcohol, ether and alkalis, and the colour of each when evaporated in a pure condition.

Tschirch and Farner's analysis.

255. The most recent and complete analysis of stick-lac has been made by A. Tschirch and A. Farner (*Arch. Pharm*, 1899, 237, 35). The proportion in which the chief constituents exist is shown in the following table:—

Pure resin	74·5	Ether insoluble	65
		Ether soluble	35
Colouring matter	6·5	Schmidt's laccaic acid.	
Wax	6·0		
Residue	9·5	Sand, wood, insect remains, etc.	
Moisture	3·5		
	100·0		

256. The resinous principles were minutely examined during the course of this investigation. After the removal of the wax by means of light petroleum, and that of the red colouring matter with hot water, the resin was dissolved in hot alcohol, and filtered into water. The purified resin formed a bulky, amorphous, light-brown powder, devoid of acid properties. The portion insoluble in ether yielded aleuritic acid and resino-tannol, which might be regarded as the resino-tannol salt of aleuritic acid. Stick-lac in this respect resembles amber in the fact that its resin contains fatty acids; all other resins, such as colophony, contain only aromatic acids. The original lac resin soluble in ether afforded a substance named erythrolaccin. This body is of a fine yellow colour, crystallises in golden-yellow spangles, sublimes in red needles, and is soluble in alcohol, ether, benzol, toluol and chloroform with a golden-yellow colour; in alkaline solutions it assumes a fine violet colour.

Aleuritic acid.

Erythro-laccin.

257. In the process of manufacturing stick-lac into seed-lac, the woody impurities and a large portion of the soluble colouring matter are removed, the former by beating and sifting, and the latter by washing in a current of water. The proportion of resinous matter consequently is increased to a considerable extent. In the next stage of the process where the seed lac is melted and strained while hot through canvas bags, further purification ensues, and the resinous matter is converted into the form of button or shellac, as required by the manufacturer.

258. The composition of the three chief commercial forms of lac is instructively represented in the following table of analyses made by

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Mr. Hatchett, where it will be seen that the colouring matter decreases and the resin increases in the finished article.—

Comparative analyses.

	Stick.	Seed.	Shellac.
Resin	68·0	88·5	90·9
Colouring matter	10·0	2·5	·5
Wax	6·0	4·5	4·0
Gluten	5·5	2·0	2·8
Impurities	10·5	2·5	1·8
	100·0	100·0	100·0

259. To further illustrate the difference in the composition of lac grain, prepared by breaking up, sifting and washing the crude lac, a series of six samples of Assam seed and dust were submitted for analysis by a firm of manufacturers near Calcutta. It was desirable to know what proportions of dye and impurities were present in each sample. It had been found by experience that the smallest grain produced the darkest lac, and it was suspected that the larger grains contained very few substances besides pure lac and lac-dye, while the smaller particles contained more extraneous matter.

Experiments with Assam sample.

260. The specimens forwarded for analysis had the following distinctive labels.—

1. Assam Large Seed Lac . . . . (11777-5).
2. Assam Clean Lac (not washed) . . (11777-3).
3. Assam Small Seed Lac . . . . (11777-4).
4. Khood (not washed) . . . . (12091).
5. Dust, Sifted from Stick Lac (not washed) . (12090).
6. Gaud (refuse after washing) . . . (12090-2).

261. The resinous matters in these samples were extracted by means of alcohol, dried in a water-bath, and weighed. The dry insoluble residue was washed with hot water and again weighed, and the balance was estimated as colouring matter. The ash and moisture determinations were made on the original products. The following figures were thus arrived at:—

	Resin.	Colouring matter.	Insoluble matter.	Ash.	Water.
1	91·5	0·5	4·9	0·5	2·6
2	84·7	3·5	7·6	1·1	3·1
3	93·7	0·4	3·5	0·2	2·2
4	72·0	3·4	17·5	3·3	3·8
5	56·2	9·2	21·1	9·4	4·1
6	56·0	4·9	30·7	2·6	5·8

262. The samples of lac were arranged in the above order, according to the size of the grains. It will be seen that the specimen most free

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from impurities is that labelled "Assam Small Seed Lac." Proceeding down the list, the percentage of resin decreases and the insoluble albuminous matter, the chief deleterious ingredient, gradually rises in proportion. It might be noticed also that the specimens of seed lac retain less moisture and ash than the inferior small-grained samples.

263. The colouring matter of these lacs was removed by employing hot water, but a small additional quantity of red pigment is separated by treating the washed residue with an alkaline solution. Alkalis remove a considerable amount of albumen from the insect or puparial remains, so that this method would be unsuitable for determining the colouring matter in analysis. On the other hand, a small amount of alkaline carbonate is advantageous in the removal of colouring matter in manufacture of seed lac. The Native workmen are in the habit of using *sajji-mati* or impure carbonate of soda for this purpose, the proportions being 3 chittacks per maund of seed lac. Used in these proportions and exposed to the sun, the lac becomes partially bleached. Caustic soda, even in dilute solution, attacks and partially dissolves the resins in seed lac, and if the solution is at all concentrated, it entirely dissolves it. The caustic alkali also renders the lac resin less soluable in spirit and make it hard and tough so as to unfit it for successful shellac-manufacture.

Removal of colouring matter.

264. *Properties of Lac Resin.*—Lac resin has a specific gravity of 1·139. It is soluble in dilute hydrochloric and acetic, but not in sulphuric acid. With the aid of heat it dissolves readily in a solution of borax. It combines with caustic potash, soda and ammonia, with a reddish-brown colour. It is also soluble in solutions of the carbonated alkalis; by passing chlorine gas in excess through the dark-coloured liquid, the lac resin becomes bleached and is precipitated in a colourless state. Lac bleached in this manner must be thoroughly washed in water and should be kept under water to prevent it becoming discoloured. When dried, it gives an excellent white varnish, particularly with the addition of mastic and a little turpentine.

Properties of the resin.

265. A solution of lac resin in carbonated or caustic alkali may be precipitated by the addition of an acid, but the lac appears to undergo some physical alteration by contract with the alkali which renders it unsuitable for shellac manufacture. The recovered lac is tough and dark in colour, and does not admit of being stretched out into sheets.

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Chemical preparation of shellac.

266. In 1843 letters patent were obtained in England by Mr. George Evans for treating the several sorts of crude lacs by a chemical method to convert them into the more useful and saleable shellac of commerce. The native method was quite unsuitable at home where labour is expensive and the habits of the people so widely different, and the absence of the smooth-surfaced, supple and moist plantain leaf is an insuperable barrier to its preparation. The method consisted in dissolving the lac in an alkaline solution and subsequently decomposing it with sulphuric acid; this left the lac in a fairly pure state differing in some of its qualities according to the material from which it was made. The plan succeeded for a short time and considerable quantities were sold in the London market, but regular supplies failing from India, and never being uniform in properties, difficulties arose in the manufacture, and the factory was soon closed at a considerable loss to the originator of the scheme. (*See Journal of the Agri-Horticultural Society of India, Vol. X, Pt. I., Jan. 1857 to June 1859, pages 50-53.*

Adulteration with rosin

267. *Adulteration of Shellac.*—The most usual adulterant of shellac is pine resin or rosin, which, on account of many of its properties being similar, is difficult to detect. An experienced dealer may recognise the odour of rosin by breaking the sample in the palm of the hand, but the proportion can only be estimated by the use of solvents or by taking the specific gravity.

Ether and petroleum ether dissolve rosin completely, while they have only a partially solvent action upon lac.

Determination of impurity

268. Dr. Julius Wiesner has suggested a process for separating these substances based on the difference of their densities. A solution of common salt or sugar is made up to the density of 1·08 to 1·09 at 15°C; resin floats, while shellac falls to the bottom of such a liquid. The sample is finely powdered and shaken briskly with the solution, which is then allowed to stand for some time. The liquid along with the floating resin is decanted, and the deposited shellac is washed and weighed to ascertain the proportion in the mixture.

Bleaching processes.

269. *Bleaching of Shellac.*—Attempts have often been made to bleach shellac and remedy the objectionable colour. Chlorine is often used for this purpose. The lac is dissolved in a weak alkaline lye and a current of chlorine passed through the solution. The gas, however, acts very energetically and often so modifies the resinous

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matter that it becomes almost insoluble in alcohol. Moreover, great trouble is experienced in removing all the chlorine, even after repeated washing with water.

1. *Willstein's Process.*—500 parts of chloride of lime are mixed with 2,000 parts of water, and a solution of 500 parts of carbonate of potash in 1,500 parts of water is run in so long as a precipitate is formed. Into the filtered liquid there is run, a little at a time, a solution of 500 parts of orange shellac in 2,000 parts of alcohol of 90 per cent It is stirred and allowed to stand in the sunlight for half an hour to an hour. The liquid containing the resin is then run into dilute (1·5) hydrochloric acid, and when precipitated, is washed with water until free from acid.

2. *Another Method.*—The above method is costly owing to the use of alcohol. 40 parts of shellac are heated with a solution of 10 parts of carbonate of soda in 150 parts of water until completely dissolved. To the decanted clear solution is added 40 parts of chloride of lime in 40 parts of water; the whole is left to stand for 24 hours, and then the resin is precipitated by hydrochloric acid as above.

3. *Alkaline Method without Chlorine.*—The shellac is added in small quantities to a dilute solution of boiling soda by taking care not to make a fresh addition until the previous lot has been dissolved. stopping short when there is a slight excess of free soda. The whole is boiled for a few moments with constant stirring, and then allowed to cool. The wax, which solidifies on the surface, is removed, and the clear liquid is treated with hydrochloric acid, as before. The product is not perfectly free of colouring matter.

4. *Elsner's Method.*—Animal charcoal is used in this method, an article which bleaches the resin without altering it. A quantity of coarse-grained animal charcoal is added to the alcoholic solution sufficient to make a fluid paste, and the whole is exposed to sunlight for several days, taking care, however, that the temperature is not too high. When the solution is sufficiently bleached, the whole is thrown on to a filter, and the filtrate is evaporated. The product is remarkably pure, but the process is costly.

5. *Sulphurous Acid Method.*—It has been further proposed to dissolve the shellac in alkaline lye and to neutralise it afterwards with a current of sulphurous acid, which precipitates the bleached shellac. (*From "The Manufacture of Varnishes, Oil Crushing, Refining and Boiling,"* by Ach. Livache).

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Lac dye.

270. "*Lac Dye.*—The dye in the ordinary course of manufacture is washed away as a red liquid when the stick or seed-lac is broken and cleaned in a current of water. The liquid is allowed to run into vats, a certain amount of lime is added to precipitate the colouring matter, the deposit is then pressed, cut into cakes, and dried." This is the usual method of preparing the dye in India, although other devices are recorded in older works. In Crooke's "Hand-book of Dyeing" it is stated that the liquid, "after filtration through coarse canvas, is evaporated in pans placed on a charcoal fire, or left to spontaneous evaporation by the sun's rays in shallow earthenware vessels." This information is obtained from an Indian source, probably from Baden-Powell's "Punjab Products." In Spon's "Encyclopædia of Manufactures," it is asserted that the filtered liquor is treated with boiling alum water and run into settling tanks to deposit the colouring matter. Here the formation of a "lake" is contemplated, but lime, and not alum, is ordinarily used as the precipitating agent. Messrs. Brooke, Simpson and Spiller introduced into commerce some years ago a lac-dye superior to that imported from India. Their improvement consisted in treating the stick-lac with weak ammonia, and adding to this solution chloride of tin, when a fine red insoluble matter is formed and precipitated. This preparation is chiefly applied for dyeing woollen fabrics scarlet; 2 to 3 parts produce the same effect as 1 part of cochineal.

Preparation.

Composition of dye.

271. *Composition of the Dye.*—The dark purplish cakes of lac-dye are sold in squares of 2 inches (52 millimetres) by ½ inch (13 millimetres). These cakes consist of 10 to 13 per cent. of actual dye, 9 to 11 per cent. of moisture, 15 to 18 per cent. of mineral constituents, and 57 to 68 per cent. of organic matter.

272. The dye was examined by Dr. E. Schmidt in 1887, who separated the colouring matter in a crystalline condition, and named it laccaic acid. This substance crystallises in rhombic plates of a yellowish-red colour, soluble in alcohols, acetone, and acetic acid. Alkalis produce with it a characteristic red colouration.

Laccaic acid

In many of its chemical properties and its absorption spectrum laccaic acid resembles carminic acid, the active colouring principle of the cochineal insect (Coccus cacti).

273. The following account by Dr. Normandy describes the application of lac-dye in England:—

"The cakes of lac-dye imported from India, stamped with peculiar marks to designate the different manufacturers (*the best* DT., the

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second JMCR, the third CE), are now employed in England for dyeing scarlet cloth, and are found to yield an equally brilliant colour. When the lac-dye was first introduced, sulphuric acid was the solvent applied to the pulverised cakes, but as muriatic (hydrochloric) acid has been found to answer, it has to a great extent supplanted it. A good *solvent* (No. 1) for this dye-stuff may be prepared by dissolving 3 pounds of tin in 60 pounds of muriatic acid, of specific gravity 1·19. The proper *mordant* for the cloth is made by mixing 27 pounds of muriatic acid of sp. gr. 1·17, with 1½ pounds of nitric acid of 1·19; putting this mixture into a salt-glazed stone bottle, and adding to it in small bits at a time, grain tin, till 4 pounds be dissolved. This solution (No. 2) may be used within twelve hours after it is made, provided it has become cold and clear. For dyeing three quarters of a pint of the solvent No 1 is to be poured upon each pound of the pulverised lac-dye, and allowed to digest upon it for six hours. The cloth, before being subjected to the dye-bath, must be scoured in the mill with fuller's earth. To dye 100 pounds of pelisse cloth, a tin or boiler of 300 gallons capacity should be filled nearly brimful with water, and a fire kindled under it. Whenever the temperature rises to 150° Fahr., a handful of bran and half a pint of the solution of tin (No. 2) are to be introduced. The froth which rises as it approaches ebullition, must be skimmed off; and when the liquor boils, 10½ pounds of lac-dye, previously mixed with 7 pints of the solvent No. 1, and 3½ pounds of solution of tin No. 2, must be poured in. An instant afterwards, 10½ pounds of tartar, and 4 pounds of ground sumach, both tied up in a linen bag, are to be suspended in the boiling bath for five minutes The fire being now withdrawn, 20 gallons of cold water with 10½ pints of solution of tin being poured into the bath, the cloth is to be immersed in it, moved about rapidly during 10 minutes, the fire is then to be rekindled and the cloth rinsed more slowly through the bath, which must be made to boil as quickly as possible, and maintained at that pitch for an hour. The cloth is to be next washed in the river, and lastly, with water only, in the fulling mill. The above proportions of the ingredients produce a brilliant scarlet tint, with a slightly purple cast. If a more orange hue be wanted, white Florence argal may be used instead of tartar, and some more sumach. Lac-dye may be substituted for cochineal in the orange-scarlets.

Dyeing in England.

274. "To determine the tinctorial power of lac dye by comparison, with proved samples, a dye-bath is prepared as follows:—5 grains of

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Testing tinctorial power.

argal 20 grains of flannel or white cloth, 5 grains of lac-dye, 5 grains of chloride of tin, 1 quart of water. Heat the water to the boiling point in a tin or china vessel; add thereto the argal, and then the piece of cloth or flannel. Weigh off 5 grains of the lac-dye and pulverise it in a wedgewood mortar, with the 5 grains by measure of chloride of tin, and pour the whole into the hot liquor containing the cloth, taking care to rinse the mortar with a little of the hot liquor; keep the whole boiling for about half an hour, stirring the cloth or flannel about with a glass rod; then withdraw the cloth, wash and dry it for comparison."

275. "The Handbook of Dyeing" by W. Crookes (page 92) contains the following process for dyeing scarlet with lac-dye:—"For 100 pounds of flannel or yarn boil in water for fifteen minutes 25lbs. of lac-dye, 15 lbs. of muriate of tin, 5 lbs. of tartar, 1 lb. of flavine (the quantity may be varied according to required shade), 1 lb. of tin crystals, 5 lbs. of hydrochloric acid, cool to 170° F., and enter the goods, boiling for one hour, rinse while hot. This is the faster colour than cochineal scarlet."

276. The following extracts from Mr. McCann's "Dyes and Tans of Bengal" will convey some useful information regarding the use of lac-dye in this Province as practised by native operators:—

Preparation of dye in Bengal.

277. "The information received as to the processes of dyeing with lac adopted by the native dyers of Bengal is very scanty, and scarcely admits of being presented as a connected account. Lac-dye is used chiefly to dye woollen and silk materials and leather. Where the cakes of lac-dye prepared as above are employed, they are first washed and pounded and then generally boiled in water for about an hour to give the dye a sufficient consistence, *alum* and an *alkali* (generally potash) being added, apparently to heighten the colour (Midnapore). In some districts alum is not employed, the dye being merely boiled with *sajji* or wood ashes (Lohardaga). In Bankura the brightening of the colour is apparently effected by boiling the dye with *lime juice.* In other districts no auxiliary of any kind is employed, the dye being prepared by merely steeping the pounded lac in hot water and then straining through a cloth (Jalpaiguri). Bark of *thanthelang* (Acacia Intsia?), which is said to be acid, is sometimes employed in Jalpaiguri to heighten the colour. The liquid obtained as above is sometimes allowed to rest, so that impurities may subside to the bottom; the upper part is then poured off and boiled again (Midnapore).

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Preparation of dye from crude stick-lac.

278. "Frequently the dye when required is prepared directly from the crude stick-lac, and not from the cakes of dye. In Maldah the Collector reports that for this purpose the stick-lac is ground, and then left to soak in water for about six hours (or a whole night) in an earthen vessel, about 12 seers of water being used for about 10 seers of the powdered stick-lac. The quantity of water is given as two maunds in another account. The lac powder is then squeezed and rubbed with the hand and 4 or 5 tolas of *sajji-mati* are thrown in whilst this is going on, and the whole is sometimes well mixed together by rubbing with the feet. It is then strained and the liquid placed in another earthen vessel and boiled; afterwards 15 tolas of the strained powder of the bark of the tree, *lodh* (Symplocos racemosa, *Roxb.*) are mixed gradually with it, and it is left to stand for a day. The scum and froth are then skimmed off, and the liquid is strained through a cloth and is ready for use. The liquid dye thus obtained is called *bol*. Sometimes this liquid is further mixed with hot tamarind-water, prepared by mixing 2½ or 3 seers of *tamarind* with 1 maund of water. The proportions given are sufficient to dye 15 yards of silk, which is simply steeped in the liquid, boiled, and then dried. The silk-dyers of Bishnupur, in the Bankura District, employ a similar process for preparing the dye directly from the stick lac, the only differences being that the ground stick-lac is left to soak in water for a day, and that, instead of *saji-mati*, alum or a solution of potash is employed. There is no mention of *lodh* bark, the dye being ready for use after the boiling.

Fermentation induced by flour-paste.

279. "In the Meetapore Jail, Patna, where lac is used for dyeing woollen yarns, the following method of preparing the dye-liquid is adopted.—The cake of lac is washed clean, broken into small pieces, and then rubbed well with a small quantity of water in a large *gumlah*. Water is then added in large quantity to dissolve all the lac, and *flour-paste*, in the proportion of 12 chittacks to 1 seer of the lac-cake, is then added to the liquid and the whole left in the sun for four days, apparently to induce fermentation. It will be found, on reference to Mr. Liotard's Memorandum, that this addition of flour-paste with a view to fermentation is generally adopted throughout the whole of India where woollen materials are to be dyed with lac. No mention of it, however, is made in any of the reports from the Bengal districts except that referred to above. The methods of preparing the dye-infusion above detailed seem to be used

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indifferently, no matter what material—silk, wool, or sometimes cotton—is to be dyed, unless special mention is made of the material.

Cleaning of materials.

280. "The woollen and silk materials seem to be generally submitted to a preliminary cleaning and preparation for the dye before being dipped in it. The Superintendent of the Meetapore Jail, Patna, reports that woollen yarns are prepared for the dye as follows:—'1 seer of the yarn is steeped in *sajji-mati* for about two hours, then washed in clean water and dried in the sun. When perfectly dry, it is again washed in a solution of ½ chittack of *lime* in water, and then dried again in the sun. It is then ready for the dye.' Silk to be dyed with lac is previously boiled for about 10 minutes in an alkaline solution, obtained generally by soaking the *ashes of burnt plantain leaves* in water, and then steeped in a solution of *alum* in water (Midnapore).

"The silk or woollen materials are simply steeped in the dye-infusion prepared as above for a longer or shorter period, or sometimes boiled with it, as in the process adopted in Maldah explained above. In some cases the material is after a time withdrawn from the dye and dried, and then again soaked in freshly prepared dye. In Jalpaiguri endi thread is soaked in the dye for six hours, then withdrawn and dried, and then again soaked for six hours in freshly prepared dye.

Dyeing in Bengal.

281. "In the Meetapore Jail, Patna, the woollen yarn is allowed to remain in the dye-infusion for ten days, being turned every day. After the tenth day the yarn is taken out and washed and boiled for six hours in a solution of 2 chittacks (?) of *lodh-bark* and ½ chittack (?) of *huldi* in 1½ gallons of water. This apparently acts as a mordant, and when the yarn is dried in the sun, it has acquired a permanent red colour. The following account given is of the method adopted by the Meches of the Darjeeling Terai in dyeing silk thread red:—'The thread is first mixed with a plant called *amlia* (**Phyllanthus Emblica**), these are boiled together for some time. The thread is then dried and coloured with lac-dye, and next mixed with the leaves of a plant called *bhauri* (**Symplocos theaefolia**, *D. Don*), and again boiled. When dried, it is of a deep red.'

"Lac-dye seems to be rarely employed in combination with other dyes to produce compound colours. A specimen of silk dyed a brownish purple by *indigo* and *lac* was received from the Rajshahi

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Division, but no details of the process adopted were given. In Jalpaiguri endi thread, dyed with lac as above without the aid of any auxiliary, has its colour heightened by boiling it for one or two hours in a mixture of *monadista* (**Rubia cordifolia**) and bark of (**Baccaurea sapida ?**,) pounded in water."

Dye liquor suggested as a manure.

282. *Use as a Manure.*—The dye liquor is a rich source of nitrogen and would constitute a valuable manure for cultivated lands. The liquor, which evolves an intolerable odour in the factory, when evaporated to the consistence of a dry extract, is equal to some of the best oil-cakes in its manurial value. A portion of the nitrogen is present in the form of ammonia, while the balance is combined as an albuminous substance. It should only be necessary to draw attention to this fact to cause agriculturists to apply for the dye as a fertiliser.

Lac wax.

283 *Lac-wax.*—The peculiar waxy matter of lac is separated from stick-, seed- or shell-lac by employing petroleum ether as a solvent. On a larger scale in the factory it separates on the surface as an oily layer when seed-lac and sodium carbonate are boiled together for some time Lac-wax is not constant in composition since it varies according to the treatment it has undergone in the manufacture. This wax has a yellowish grey colour, and is said to melt at 59°– 60°. A sample of lac-wax lately supplied to the Indian Museum, by a local factory, had a melting point of 78° C and the characteristic odour of the raw material

Composition of wax.

284. Lac wax was the subject of an investigation by Messrs. Benedikt and F. Ulzer in 1888. By treatment with alcoholic potash, the authors were able to separate stearic, palmitic and oleic acids together with myricyl and ceryl alcohols The wax contained altogether about 50 per cent. of free alcohols of this nature.

This wax is allied to the insect wax of China secreted by **Coccus ceriferus**. Chinese insect wax is used for making candles, for polishing furniture and leather and as a sizing for paper and cotton. On account of its extensive use in China and Japan it is not exported to Europe. The only vegetable wax which bears any resemblance to that secreted by species of **Coccus (Tachardia)**, is the Carnauba wax, a natural exudation of the Corypha palm of tropical South America, but no wax of this description has been found in India.

Properties of Lac wax

285. *Properties of lac-wax.*—In the chemical process of purifying lac, alluded to on page 298, Mr. Evans obtained about 1 per cent. of lac-wax as a bye-product. It was harder and more resinous than

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Properties.

common bees-wax and possessed an agreeable aromatic odour. It combined with paraffin, spermaceti, bees-wax, some of the resins, tallow and animal and vegetable oils. With tallow it made excellent candles, yielding a bright and pure light, but it gave off much smoke when burnt by itself. Its chief use, provided it could be obtained in quantity, would be for making castings, and taking impressions of coins and medallions. It possesses a slight degree of contractibility, it sets rapidly, and its peculiar hardness and freedom from stickiness cause it to quit the mould or object on which it has been applied. Its non-liability to be affected by atmospheric conditions would also render it useful for large seals attached to parchment documents.

Arsenic in lac toys.

286. *Arsenic in Lac-Ware.*—It is well known that yellow sulphide of arsenic (orpiment) is used in the preparation of shel-lac, and as the base of the yellow and green colour of lac toys. Orpiment is an insoluble compound of arsenic, and even in a powdered condition may be handled with impunity. When the toys are well finished by the artisan, and the oil has been thoroughly applied, the colouring matter remains for any length of time in an innocuous form. A danger, however, arises when the water-proofing or varnishing is imperfectly accomplished, and the acids of the lac resin acting on arsenical paint in contact with the air, produces a decomposition of the compound and renders a portion of it soluble in water. Some old specimens of lac toys exhibited in the Indian Museum have shown the presence of arsenic oxide on the application of chemical tests. It is well to draw attention to this fact to show that the commoner kinds of lac toy should not be purchased as playthings for children.

CHAPTER VI.

USES OF LAC.

INDUSTRIAL AND ART USES OF LAC.

287. Lac enters into the agricultural, commercial, artistic, manufacturing, domestic and sacred feelings and enterprises of the people of India to an extent hardly appreciated by the ordinary observer. The existence of the poorer communities in the agricultural and forest tracts is made more tolerable through the income derived from the collection of the crude article. Employment is given to a large number of traders and manufacturers regularly concerned in the production and sale of the various grades of the prepared lac and lac-dye.

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288. *Diversity of Indian uses.*—Every village has its carpenters, cart-wrights and turners, who all use lac in some form or other, either as varnish or colour medium in the production of tables, bed-posts, chairs, boxes, platters, carts and carriages, pails, candle-sticks, powder-boxes, pan-boxes, etc., etc. The silver and copper smiths employ lac as a bed upon which to hammer and punch certain of their wares or to effect coloured ornamentations on these in imitation of enamelling and inlaying. The manufacturers of shields, swords and scabbards use lac as a varnish, while the lapidaries make their grind-stones of the same material as they employ to cement blade to haft. The potters, book-binders and makers of smoking-pipes also use lac as a varnish and stiffening material. Painted pottery may be said to have attained a definite position in Sasseram in Bengal, Gonda and Lucknow, in Oudh and Peshawar, in the Panjab, and in these instances lac varnish is used to fix the colours. Occasionally coloured lac is directly applied to pottery and patterns are elaborated upon it by etching (as for example at Kotah) in a manner shortly to be described in connection with turnery. The jewellers load their hollow gold and silver ornaments or fix the stones in jewellery with the same substance. The makers of humbler personal ornaments, prepare the *churis* (bracelets) of the poorer classes of lac and cleverly (through the same material) cause a surface dressing of tin to assume the effect of gold. The dyers and tanners employ lac in the production of some of the more brilliant shades of red and purple given to silken and woollen fabrics or to skins and hides. The producers of agricultural and industrial implements, utilise lac as the chief means of ornamentation, as, for example, with milk-churns, shuttles, spools, bobbins, spinning and weaving appliances, etc., etc. Lac-dye figures as a cosmetic, since it is often used to stain the soles of the feet and the palms of the hands of Hindu ladies. Lastly, in the hands of the toy-maker lac is supreme. All sorts of toys are coloured by it, such as playing-cards, tops, nests of boxes and sets of wooden tea dishes, etc., while marbles, pens, sealing-wax, ink-bottles, imitation flowers and fruits, etc., etc., are entirely made of it.

289. *European Uses.*—In a word the Indian uses of lac are as numerous and diversified as its possibilities of future European development are great. Already it finds a by no means humble position in the commerce of Europe and America. It is extensively used as a varnish and polish for furniture and metal; as a stiffening

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material for hats; as an ingredient in lithographic ink, and as sealing-wax.

Antiquity of the Art

290. *Antiquity of the Art.*—Lac is perhaps one of the most ancient and most widely known materials employed in wood and metal ornamentation. Certain towns of India have from the most ancient historic times been famous for the rich blending of colours, the depth of tone and the fine polish which their turners (*Kharadis*) have been, and are still, able to impart.

Lac versus Lacquer.

291. *Lac versus Lacquer.*—It seems desirable that a distinction should be here made between lac-turnery and the class of goods commonly known as lacquer (lacker as it formerly and perhaps more correctly was expressed). By modern usage the latter term has come to be applied to varnishes mostly of *vegetable* origin, applied by a brush in *a liquid condition*, the articles being coated at the same time with mud, saw-dust or other substance and repeatedly painted with the varnish and rubbed down again and again until the degree of polish and thickness of coating desired has been attained. Lac ornamentation, on the other hand, is produced from an *insect* resin and is applied in a *solid form*, the heat generated by friction being the agent of its uniform distribution.

292. The art of lacquering has been carried to a high state of perfection in China and Japan. In Burma (Prome), South India (Karnul), Hyderabad (Raichur), Rajputana (Tonk, Bikaner, etc.) and in Kashmir, forms of lacquering are also practised, but these are essentially different in material, manipulation and art feeling from the lac ornamentation. The lacquer of India is in fact much more closely related to that of China and Japan than to the lac-turnery which is the subject of the present paper. Indian lacquer has, therefore, been reserved for a future issue in this publication. But it may be added that of course there are lac varnishes—preparations of lac dissolved in spirits of wine for the most part— that would come to approximate very closely to the lacquers indicated, so that the distinction into lac-turnery and lacquer-ware while convenient and useful is not a logical separation. The present article will indicate briefly the chief varnishes used in India of which lac may be regarded as the chief ingredient.

I.—LAC-WARE OR LAC-TURNERY.

293. With these introductory remarks it may now be convenient to indicate some of the more striking examples, in manipulation and

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LAC-WARE OR LAC-TURNERY.

style, of lac ornamentation practised in India. I would here explain that for all the finer classes of lac-turnery only the purest forms of shell-lac are employed. The inferior qualities of lac find their place in the other industries for which lac is a necessity. It would also appear that certain results can alone be attained with a particular timber or when a certain combination of colours has been employed Hence it follows that a study of the timbers and of the pigments is essential to the full appreciation of the art of lac-turnery. I propose, however, to indicate the chief types of that art first and to revert to the question of the timbers and pigments later on. There may be said to be the following styles of lac-turnery :—

Plain Ornamentation.

294. ***Class I.—Plain Ornamentation.***—An article intended to be ornamented with lac is first turned to the desired shape and polished with a fine powder made from broken pottery. This polishing has the effect of filling up the pores. Should cracks or joints exist, these are plugged up with wood, inferior lac or other materials, and at the same time pieces of cloth are often glued across such imperfections Articles so treated are subsequently coated repeatedly with a preparation of glue and pottery dust. They are polished after each coating with a sort of chisel made from the leaf-stalk of a palm All the imperfections and joints are thus made to disappear completely and a smooth and uniform surface is produced. If no cracks or imperfections exist in the wood, the article, after being turned to the desired shape and polished with pottery dust, is directly coated with the colour. For this purpose the *Kharadi* (or turner) takes a stick of coloured lac (a *batti* as it is technically called) and presses this against the prepared article while it revolves on the lathe. The heat generated by friction melts the lac and causes it to adhere to the revolving object. By means of the wooden chisel the lac is still further distributed. The article is lastly polished by a cloth rag, moistened in sesamum or linseed oil. And a peculiarity of this oil-produced polish is that it is not subject to tarnish or to rub off, hence it effectually protects the lac from atmospheric influences.

295. The art of plain lac ornamentation is practised all over India, especially in the preparation of wooden toys, bed-posts, pan-leaf-boxes, etc. The better results attained are for the most part due to several layers of colour and polish having been imparted, the one on the top of the other.

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296. With practically the one exception, *viz.*, indigo, all the other colouring ingredients employed in the manufacture of lac *battis* are minerals, such as orpiment, sulphur, white-lead, red-mercury (vermillion), Prussian-blue, lamp-black, etc., etc. Lac-dye is, however, sometimes used, and in the inferior and modern productions aniline dyes are unfortunately now-a-days extensively employed.

Abri or cloud work.

297. *Class 2.—Abri or Cloud Work.*—The turnery after being polished or glued and polished in the ordinary way (Class I) has a coating of yellow lac applied all over. The operator then takes in his hand specially prepared *batti* of red or orange colour. This is exceptionally hard, round, sharply pointed and not thicker than a lead pencil. In some cases the pigments used in colouring these hard *battis* would appear to have been dissolved in oil a fact often claimed as a special feature in their production. By allowing the hard *battis* to tremble in the hand and to thus touch the revolving object interruptedly, numerous irregularly shaped spots of various sizes are imparted. By next using a black *batti* of the commoner large flat shape and soft texture, black borders are communicated to the red spots. The remaining interspaces are lastly filled up by means of a white *batti* also of soft texture. But any number of colours may be used, the isolated spots being first imparted by specially prepared hard and sharply pointed round *battis*.

By various modifications of the process thus briefly indicated are produced the pleasing cloud effects that have given origin to the name *Abri* for this class of lac ornamentation. It is practised all over India, but seems to be carried to the greatest perfection in Hoshiarpur in the Panjab, and in Bombay and Sind the art is carried to a high proficiency. In Bengal the spots first imparted are larger, more elongated and less artistic than in Hoshiarpur and the black fimbriation is never practised.

299. From Marara comes another form of Abri-work. A mixture of oil and water placed on the surface of the first coat makes a "watered" cloud-pattern where application of a water *batti* only takes in part. The opaque water colours—ochre or green with a black border—are often made to overlie a transparent polished oil-colour. Modified, this method gives spots, the water being placed in drops to form a pattern.

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Copy of the letter No. 3327, dated the 23rd July 1896, from the Collector of Haidrabad, Sind, Haidrabad.

Sind (Haidrabad). Lac-work of the Haidrabad District.

300. "With reference to correspondence ending with your letter No. 2097—170 of the 10th instant, on the subject of lac-turnery, I have the honour to subjoin the particulars asked for by you.

"I send herewith a packet containing 6 circular boxes, illustrating the various stages of the simplest form of manufacture. The smallest box (marked 1) illustrates the elementary stage and shews a piece of wood roughly hewn into a box by means of the carpenters' adze. *The wood is first cut and formed into a block resembling* [illegible] ·rical and the lower circular [illegible] lathe and smoothed with a [illegible] ts, each of which is hollowed out by means of an instrument, called in Sindhi, *Bachi* (a 'turner's point' for hollowing with). Box No. 2 among the specimens represents the stage of manufacture at which it is generally ready for colouring. This is done by applying the yellow colour by pressing a stick of coloured lac against the article while on the lathe, thus making box No 3. Next comes the process of putting drops of lac on the upper surface of the article as illustrated by box No. 4. Red colour is then applied, see No. 5, and after it is dry, the article is placed on the lathe and smoothed by means of an instrument, called *Khujan* (a kind of file). A little oil is next applied. This gives the colour a sort of brilliancy which is further enhanced by pressing a piece of rag against the article while it is revolving on the lathe. See box No. 6.

Atishi or Fire-work.

301. *Class 3.—Atishi or Fire Work.*—The peculiarity of this style may be said to be that, after the article has been carefully prepared and polished with pottery-dust, it receives a coating of finely divided tin made into a paste with glue, the coating being either uniform or made up of a multitude of minute dots after the fashion of the *Abri* work (*Class II*). Over the top of the tin, red or yellow lac is next applied, with the result that the object obtains a rich fiery or golden glow. *It is then polished on the lathe by means of a shell, known as* the *mohra*; this communicates so much heat that the lac becomes more transparent than is the case in the other methods of lac ornamentation.

302 *Atishi* is largely practised in Hoshiarpur, Jampur and [illegible] Ghazi Khan, in the Panjab. Without exactly manifesting the [illegible] glow, the lac toys and boxes of Indergarh, in Rajputana, [illegible] Podanur in Madras, exhibit a depth of colour and purity [illegible] that approaches closely to the *Atishi* style.

C. [illegible]

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At Marara, *Abri* work of the type described over a sheet of tin-foil laid on the wood produces a very pleasing effect, the ground colour made transparent, allows of the reflection of light from the tin below and the clouds lie opaque on it.

Nakshi work

303. ***Class 4.–Nakshi (or Pattern) Work.***—Of this style there are two well-marked sections.

(Section A.)—Oiled and Scraped Nakshi.—An example of *Atishi*-ware (*Class III*) polished with *pipa* (brick-powder) and with mustard oil, has patterns, floral designs, or hunting scenes, etc., etc., subsequently worked on the surface. This is accomplished by scraping off lines loops, or patches of the polished and oil-varnished surface and then applying a soft flat *batti* as the article revolves on the lathe. The portions scraped off receive the new colour, but none of the intervening oil-varnished spaces do so. The object is again polished and oil varnished all over and further portions scraped off when these in turn are given the next colour that may be desired. This is repeated time after time until the floral and other designs or pictures have every outline and detail of colouring imparted to them.

This art attains its highest perfection in Hoshiarpur in the Panjab, but is less skilfully practised in other districts Such as at Bagri and Sojat of Marwar in Rajputana.

304. Rao Bahadur P. Sukdev Prashad, Judicial Secretary to the Masaheb Ala of Marwar, describes a beautiful modification of scraped Nakshi. He lays special stress on the fact that certain coloured *battis* (or lac sticks) have been prepared with oil, others with water. A bed-post coated with a red oil-prepared *batti* has numerous straight parallel lines ⅛th inch apart scraped off certain portions. By means of a yellow water *batti* then become lines of yellow or other colours on the red back ground. The bed-post is next made to revolve rapidly on the lathe and a rag of cloth moistened in oil is firmly pressed against the lined portion. The heat generated melts the coatings of lac and drags the lines into beautiful wavey courses.

305. A special reference was made to Haidrabad, Sind, in order to procure information regarding the lac-turnery for which it used to be famous, *viz.*, that with painted hunting scenes. That particular branch of the industry may be found described on page 316.

The following passages from letters received would appear

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to allude to scraped Nakshi and are accordingly given in this place:— LAC WARE AND LAC-TURNERY.

Extract from letter No 946, dated the 2nd March 1897, from the Collector of Haidrabad, Sind.

306 "In reply to your letter No. 2400—170, dated 6th August 1896, I have the honour to forward copy of a letter to my address from the Assistant Collector, Hala,* in which that officer gives a further account of the industry in lac and lac toys, and trust that it will prove to be what you require

"The colouring of animals and flowers is also not very accurately described by the Assistant Collector. The workman digs out the pattern or figure which he wishes to make upon the wood after the surrounding back ground has been coloured. He then applies to the whole block the colour which he wishes to give to the flower, for instance, having laid on this colour sufficiently thickly, he scrapes it off again until the original colouring of the back ground once more appears The colour which has been given to the flower and which has sunk in below the surface of the back ground remains. The process of sinking in colour and then smoothing it down can be repeated indefinitely."

Process of describing figures and circles on the work

307. "After the wood has been brought to the stage, when *Khurchan* is used the process of scraping with it is dispensed with and it is smoothed with the palm bark, then with an instrument called *Rachi* (an iron bar about 10 inches long, ¾ inch thick and pointed at both ends) and a compass, figures, and circles are described with the hand on the toys, etc., which are then again placed on the lathe, smoothed with the bark and *Khurchan* oiled and cleansed with a rag finally coloured and the colours sticking into the cavities created in the process of scraping the figures." Figures and circles work.

308 (*Section B*)—*Etched Nakshi*—In this class of turnery the object is coated with first one colour, then on the top a second, a third or a fourth, uniformly all over The *battis* employed are for the most part the common soft flat kind. The first colour is usually yellow, the next red, followed by green and last of all by black; but of course any assortment or number of colours may be imparted layer upon layer, the one on the top of the other. Etched Nakshi.

With a fine chisel or style the lac-coated surface is now scratched, the hand being made to move lightly or to press heavily as may be necessary to bring out the colour required from the numerous layers beneath the surface. In this way, upon a black back-ground, yellow

* Passage from the Assistant Collector of Hala's Report alluded to above.

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stems and leaf-stalks, green leaves and red flowers with yellow or parti-coloured veins and shadings may be elaborated.

309 In Pak-Pattan and Montgomery the floral designs usually produced, manifest a softening and blending of the colours that bespeak great skill and delicacy of touch In Ferozpur the fern-like ornamentation assumes a geometric arrangement of spaces. In Dera Ismail Khan ivory bottons or discs are given as centres for an elaborate and minute floral pattern. In Sahiwal of Shahpur in the Panjab a bold open style of this art is practised in which two colours only are as a rule employed The surface colour is usually a dull black and the etched pattern is in the second colour, *viz.*, red, yellow or green. The design has a strong Greek feeling and is perhaps the more artistic because less elaborate than the style of Pak-Pattan, Montgomery, Ferozpur and Dera Ismail Khan. In Jaipur hunting scenes are cleverly etched in which the shading and colouring of the figures is attained through the varying degree of pressure given to the chisel.

310 In Agra two colours only are as a rule used, red and white, black and white, etc, the lighter colour being underneath, so that the pattern shows up somewhat severely. The pattern is mainly floral the colouring or shading of the petals being brought about by parallel lines. In Indergarh and Gainta towns of the Kohat State in Rajputana, two very distinct schools of this class of lac-turnery exist. The Indergarh style may be said to be characterised by great depth and purity of colour with a boldness and sharpness of design that is very charming. As a rule four colours are employed, the petals of the stellate flowers etched out being parti-coloured. Gainta, on the other hand, is strongly aboriginal. Alternate bands have either a green or a yellow pinnately floral design with spirally formed flowers elaborated on a dull black back-ground. Brighter colours seem never to be resorted to and the patterns closely approximate to the cross-stitch embroidery of the wild hill tribes of Rajputana. Some work from Marwara has a similarity of pattern.

311. Throughout India the art of lac-etching is known and practised, the designs varying with the art instincts and religious feelings of the people. Usually it is only resorted to for the illumination of small portions, such as the borders, of otherwise plain lac-ornamentation.

312. The following passages from the writings of authors or the com munications of an extensive series of generous correspondent

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may be given in anticipation of the foregoing observations regarding this art:— LAC-WARE AND LAC-TURNERY.

Extracts from letter No. 3630, dated the 6th June 1896, from the Collector of Agra.

313. "In reply to your No. 369—170, dated the 21st February ... oods Agra.

... y is carried on are Ferozabad, Falehbad and Agra; but in all places except Agra city itself, the industry is confined to manufacturing and colouring small toys for children. In Agra city considerable progress has been made since 1878, so that in addition to toys the artisans here prepare small boxes of different descriptions, cups, saucers, baskets, small tables, frameworks and stands for looking-glass ... not c ...

3 ... Etched lac-turnery.

ably ... colour, or super-coated. The article is then varnished. Any ornamentation that is needed is done afterwards by hand, with steel-pen, which scratches out the outer colouring or coating, leaving the yellow ground-work exposed. The portions thus exposed are then coated over with a solution of old lime or chalk, and after the solution has dried up the article is rubbed over with a duster and is ready for the market.

"The articles sent to you have all been supplied by Mian Jan, son of Ghis Mohammad of Kharade tola, Agra, who requires no payment for them. He only stipulates that if any of the articles be considered fit to be kept in the Museum he should be named on the label as the donor."

Extracts from note on the Indergarh Lac-work industry in the Kotah State by Babu Durga Pershad, Hakim *Kotrlat, Kotah.*

315. "Indergarh, the capital of a Chiefship of that name in the Kotah State in Rajputana, is noted for its lac-work industry. Wooden articles are coated with one or more layers of lac of different colours on which various designs are traced. Circular boxes, balls, toys and sundry nick-nacks are made in this way; particularly lacquered wooden cups, goblets which are used for toilet purposes. Kotah.

"Blocks are prepared first with a *Basoola* (Indian adze) and ...

by the assistant The instruments used for shaping the exterior and interior of the cups are called '*Nohlia*' (a sort of gouge) and '*Kholna*' (brad awl), a common chisel, is used for smoothing the surface.

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"When the cup is ready to be coloured, it is first coated with one or more, but never more than four, layers of lac of different colours, and then the designs are traced with a sharp edged chisel, the required colours for flowers or leaves in a floral pattern being obtained by cutting the layers to the required depth.

"The coatings of colour are laid on the wood whilst on the lathe in the following manner:—

"While the cup is rapidly revolving, a stick of coloured shell-lac is pressed to it and the friction develops sufficient heat to make it adhere to the wood, and then a piece of *Khajoor-ki-dandi* (the leaf of the date palm), or *Khajoor-ki-ghar* (stem of the date fruit), and *Keora-ka-patta* (leaf of the screwpine) are pressed successively against the revolving surface to make the colours smooth and glossy.

316. From Indergarh an interesting series of etched lac-ware has been received, amongst which may be mentioned the *Singardans* or groups of dome-shaped toilet boxes; the *phul kanwal* or lotus flower that unfolds its petals on the screw being turned; and imitation flowers and fruits. From Gainta have come sets of Singardans on stands and a curiosity in the form of *Basudeojee-ka-dibba* (a box containing an image of "Basudeo," the father of "Krishna," when water is poured in the box it will remain in the box so long as it does not touch the feet of "Basudeo" but as soon as the water does so, the box will become empty—the water running out).

Lastly, *Painch-ka-dibba* or box that cannot be opened or shut until certain marks are brought into a required position.

Painted Ornamentation.

317. ***Class 5.—Painted Ornamentation.***—In this class of the work articles to be ornamented are repeatedly and carefully coated with glue and fine pottery-powder. Thereafter they are elaborately smoothed and polished When a sufficiently good surface has been obtained, certain portions (panels or medallions) upon which bunches of flowers, groups of animals, hunting scenes or mythological pictures are to be given, receive a coating of white paint or chalk. The desired illuminations are then made in water colours, and, when quite dry, are varnished. The articles are thereafter again placed on the lathe and the designs completed by one or all of the methods of lac ornamentation.

318. This art attains its highest perfection in Haidrabad, Sind, and in Jaipur and Alwar. In Benares and elsewhere crudely painted designs are sometimes given to otherwise plain lac-ornamentation.

Extract from a note on the Jaipur Lac-work by Colonel T. H. Hendley, C.I.E., *furnished with the Resident's letter No. 3484, dated 12th December 1896.*

319 *Painted Animals*—"These figures are painted in the usual wall painting process. The ground is first prepared with a coating

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of powdered *Thickri* (Kilned earthenware) and boiled glue—a cloth rag is used to cement the joints to prevent cracking by shrinkage from the atmosphere—as many layers of cloth are applied as are necessary, and of this the painter is the judge. Then coating with white lead is applied, and Turpentine and *Chandra Rojan* (varnish) which is called *Bat* (*Safeda-ki-Bat*). This *Bat* is applied over and over again until the required surface gets perfectly smooth and then an animal, or a hunting scene, or any figure to the fancy of the painter is drawn upon it in water colour and varnished with the *Chandra Rojan* as said above, which process is called Abdara by the painters.

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Painted animals.

Abdara.

320. ***Class G.—Coloured Metal Ware such as Produced at Moradabad.***—Lac is very largely used in the metal industries, both to impart colours in imitation of enamelling and inlaying and as a varnish to improve or preserve the colour of the metal. This art may be briefly described as follows. The vessel is cast in a mould in the ordinary way. It is then filed down roughly and later is placed on a turning lathe (*chhalai*) where it is ground into final shape and polished by means of an iron chisel which is sharpened on the stone known as *Korant-ka-pathar* or corundum The vessel is now placed on a bright coal fire and made red hot. It is then sprinkled with powdered *Nausadar* (sal-ammoniac) and rubbed with *Ranga* (pure tin), the *Ranga* being diffused by means of a cloth dipped from time to time in the powdered sal-ammoniac The vessel thus tinned is allowed to cool. It is next deeply engraved Once more it is placed on the fire. This has the effect of temporarily dulling the tinning but of making it more durable. While still hot, sticks of coloured lac (*battis*) are rubbed over the portions of the surface that are intended to receive colour. The vessel is then allowed to cool and is once more placed on the turning lathe. Ashes mixed with powdered pottery or brick-dust are sprinkled over the surface and well rubbed in by being held firmly between dry leaves of the date-palm. A mixture of powdered emery (*korant-ka-pathar*) and linseed is similarly pressed hard on the vessel as it revolves on the lathe. The result is that all the coloured lac that had adhered to the higher portions is removed, while that within the engraved portions remains and at the same time the surface is beautifully polished.

LAC-COLOURED METAL WARE.

321. A somewhat remarkable feature of the ornamentation of metal objects with lac is that the green and purple pigments employed are aniline dyes. The red is, as a rule, red oxide of mercury and the black lamp-black, but the gaudy colours that have recently been

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introduced and which have degraded and demoralised the art, are all aniline. Formerly Moradabad-ware had a distinct position of its own. The back-ground was uniformly black and a rich floral design, partly in silver and partly in gold colour, was traced in imitation of the inlaid *Koftghari* of Sialkot, the Niello of Burma or the Bidri of Hyderabad. In fact, so elaborate and beautiful was the sunk lac that the elevated metal design was by most persons taken as inlaid wire. All this has practically vanished. The patterns now worked are large blotches of green, purple, black and red and are as vulgar and inartistic as it is possible to conceive. Moradabad-ware has no longer a style and recognised position of its own, but, like the Jaipur pottery in Bikaner lacquer, it appeals to the vulgar craving for novelty at the expense of artistic conception and suitability But it is perhaps worthy of note that the monstrosities that have of late appeared have for the most part not been produced at the ancestral home of the industry.

322. A recent Moradabad development, not devoid of merit, may in conclusion be mentioned, *viz.*, that in which the design appears to be worked in black the back-ground being a polished brass surface. This while not inoffensive, is doubtless less troublesome and expensive than the older style where the engraving was carried to such an extent that all that remained of the original metallic surface was a delicate floral design in what appeared silver and gold wire.

OPINIONS OF AUTHORS.

SOME ACCOUNTS OF LAC IN INDIAN ARTS.

323. In amplification of the foregoing observations regarding the various classes of lac-turnery that exist in India the following extracts from published works and correspondence may be here given. It will be observed that the passages to follow deal with all the classes already described, but in such a manner that they could not be cut up and distributed under sections without being seriously injured.

Passages taken from the Hand-book of the Manufactures and Arts of the Panjab, by B H. Baden-Powell, Esq., I C.S. C I E., *pages 211-213.*

Turned and Lacquered Ware.

324 *Turned and Lacquered Ware.*—There are two prominent kinds of work which deserve separate mention: one is the *Kár-i-kh arát* or turned and lacquered ware, known to the Europeans by the name of Pakpatan work; the other, the turned work of Dera Ismail Khan.

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325. The kharat work consists of turned wood boxes, cups and toys, the outer face of which is prettily coloured with a coating of mottled lacquer.

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326. The best work in the Panjab is done in the Montgomery

separate notice.

327. The lacquered work has a fine polish and generally a marbled or mottled appearance, often in two or three colours, and the article finished with a flowered border which latter is done by a species of handiwork different from the rest, and certainly affording a good instance of the delicacy of native handling.

The process of making the lacquered ware may now be described:—

upright is capable of adjustment at a quarter or less distance, according to the size of the work—it slides along the under bar of the frame, and is fixed by a peg in one of a series of holes in the bar. When adjusted to the required distance, a piece of hard wood, ron spike in the fixed a hole in the second, points between the

The machine is kept going by a small apprentice, who saws away with the bow, and is supposed to learn the art meanwhile.

So soon as the article has attained the required shape, it is ready to be lacquered. (*balli*), of a is said, with a

w is made with d lead or ver- blue ("wilaiti nil"). But a pretty transparent crimson is produced with the red of the lac-insect; and black with lamp black. When about to apply the sticks of lacquer colour, the wooden article duly smoothed and clean, is set on the turner's frame and made to rotate. If the colour to be produced is an uniform surface of lac colour, the lac-stick is pressed rather hard against the wood and the colour

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comes off, as the heat produced by the friction is sufficient to soften the lac and detach a portion. When enough colour has been applied, the article looks dull and streaky, but a piece of bamboo is taken and a fine edge put on it with a chisel; this is skilfully rubbed over the surface of the article till the colour has evenly spread, and by skilful manipulation a polish begins to show on the surface, which is enhanced by a gentler application of bamboo edges, and finally completed with oil and rag. To produce the mottled appearance so much admired, the sticks of colour are selected of a rather harder composition, and less easily softened by heat. The article to be coloured is set revolving, and the workman, holding the colour stick against it very lightly, allows a point here and a point there of colour to attach itself; the wood soon appears to be sprinkled over with coloured dust.

The workman takes another colour, and repeats the process moving the stick up and down along the revolving block, when by his skilful manipulation the second colour adheres at points which the first colour has left blank, sometimes a third colour is touched in in the same manner. When enough colour is on the surface, the different points of colours are rubbed together and combined into a mottled or marbled appearance by rubbing, as before described, with a bamboo edge, and finishing with a rag and oil The prettiest mottle is that of crimson and black, crimson and white, and blue and black. Around the rim of a box or lip of a cup, a border is often put on, with a flower pattern on it, which is done in a different way.

The article is again set spinning on the frame, and colour applied where the desired border is to come, in a uniform band, and well rubbed in and smoothed with the bamboo; a coating of red is always given first; over the red, a coating of green is applied till the red disappears, and over the green, black.

The flower pattern is produced by hand with a small sharp chisel; so delicately does the workman adjust the force and depth of his cut that he will, for the flower, let us say make it appear

[illegible]

the whole.

330. *The turned work from the Deráját (Dera Ismail Khan) differs* from that of Pakpatan. The variety of articles made is much less: the favourite article is a round box with a domed lid. The mottled surface is not given; but three coats of colour, red, green and black, are applied as just described, and the pattern entirely produced by the chisel. The lines produced are often silvered with an amalgam of mercury and tin-foil and the appearance is very pleasing. The boxes are further ornamented by carved ivory knobs, etc.

331. It will not be interesting to give a list of specimens. At Pakpatan all kinds of cigar boxes, vases and trays, croquet mallets and balls, children's toys, etc., are made, and a list of them would be useless.

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ARTWARE MANUFACTURES OF LAC IN THE PUNJAB.

I conclude the class with a descriptive list of the turner's tools :—

(1) "Nán."—A large, heavy, narrow-bladed chisel, for the first operation of rough clearing the wood.

(2) "Nihán."—A broad chisel, rather heavy, with long wooden handle, for neat cutting; also called Máthna.

(3) They rest their tools on an iron bar "addi" placed close below the revolving block of wood, and press the edge of the tool against the wood, moving it from side to side.

(4) "Buráki."— [illegible]

(5) "Chírná."— [illegible] either en[illegible] edgewise. Grooves can be cut, and a cylinder separated into pieces by this.

(6) "Rachí," and "Roda."—A bar worked into a blade at either end.

(7) "Sathra" "Sathrí."— Narrow edged chisels of sizes.

(8) "Bánkiya" for cleaning out the inside of vessels intended to be turned hollow It is like a hooked bar, the edge of the hook being flat and sharp.

(9) "Tesha."—Adze.

(10) "Rangáta"—The polishing stick.

(11) "Varma" of sizes.—This is the universal tool for boring holes.

He has also saws and files, which need no description.

Passages taken from the Indian Art Journal, Vol III., April 1890, page 30

Lacquer work and Turnery.

332. *Lacquer-work and Turnery.—The Kharadi* (turner) is found in every town and large village. His work is to be seen in every villager's house. Much of his work is crude in design and colour, and rough in execution, but it improves *pari passu* with the increase in refinement and wealth of the purchasing public: thus the manufactures of the city-turners are in general better in quality than those of his village brother.

333. The turner's instruments are rough and primitive, and are mainly *country-made. In common with the rest of the tarkhan* class, however, he is slowly finding out the merits of English steel, and one frequently finds that his chisels, saws and files are of English manufacture —(1) The lathe (*adda*) consists of two iron bars (*killa*), [illegible] adjusted for distance. On [illegible] ..ich the block of wood to be [illegible] this block and the adjusting peg (*chari*), round which the thong of the bow (*kaman*) is once passed. The bow is worked backwards and forwards, and thus imparts the necessary rotatory motion. (2) *Nan, nihan*, heavy chisels for the operation of rough cleaning the wood. (3) *Mathna*, a light chisel. (4) *Addi*, the rest for the chisel. (5) *Buraki*, a pointed chisel for grooving. (6)

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Sathra and *sathri*, narrow-edged chisels of sizes. (7) *Churna, rachi, roda*, an iron bar, ends flat-bladed, the edges sharp for separating the cylinders, etc. (8) *Bomkinja* or *patra* for cleaning out the insides of vessel to be turned hollow. (9) *Tesha*, the adze. (10) *Varma*, the drill (11) (*Ari*) saws and (*reti*) files. (12) *Rangata*, the polishing stick, etc. The woods used are shisham and poplar.

334 After the articles have been turned to the required shape on the lathe, the colour is applied by pressing sticks (*batti*) of coloured lac to the revolving surface. Sometimes two or three colours are laid on in patches to produce a mottled or marbled ground (Dera Ismail Khan). Borders are usually made in two or three colours superposed and the pattern is etched with a chisel. When colours are superposed, the invariable order is first red, second green, and third black. The coating of colour is rendered even by means of the polishing stick, a piece of bamboo, or the midrib of a palm-leaf. To produce a pattern in green the black is scraped through, for red both the green and black are scraped away, and for white the wood itself is exposed The lac stands well the extreme heat of the sun and the damp of the rains, but cannot be compared in these qualities to Japanese lacquer-work

335. The colours are mostly mineral. Yellow is made with orpiment, green is the arsenite of copper, red with red-lead or vermillion, blue with *lajward* or Prussian blue, black with lamp-black. The usual method of manufacture is as follows.—Yellow—Quarter seer shell-lac and 2 chittacks sulphide of arsenic (*hartal*); pound the latter in a mortar, mix the shell-lac in, and warming gently, mount the mixture on a stick, cool, and take off the pigment and roll it into a cylinder (*batti*) Red.—Quarter seer shell-lac and 2½ chittacks of vermilion; treat with water and pound for several hours, dry and mix with shell-lac and proceed as for yellow. Green.—One chittack yellow; warm and mix one tola of indigo and proceed as before. Black.—Quarter seer shell-lac and 2 chittacks lamp-black, etc. Blue.—Quarter seer shell-lac and 2 chittacks carbonate of lead; pound and mix indigo, etc. *Lajward*—Quarter seer shell-lac, 2 chittacks white lead, and 4 tolas bottle colour (*ajaib rang*), warm shell-lac gently, mix the two other ingredients slowly, etc.

Centres.

336. The following places may be regarded as centres of the trade:—Sahiwal (Shahpur District), Dera Ismail Khan, Pakpatan (Montgomery), Ferozpur, Hoshiarpur and Jullundar. Sahiwal lacquer work, as compared with that of other centres, is rough and crude. It is, however, characterised by great freedom in design. Aniline dyes are much used, an aniline mauve being peculiarly unpleasant. The work done in two colours is most effective. The Dera Ismail Khan work is unique in character, very few colours are employed, and the pattern is usually of fern-like scrolls of almost incredible minuteness and delicacy of execution, mostly wrought or scratched by women. The caskets, tables, etc., are lavishly ornamented with ivory studs, flowers and similar ornaments. Pakpatan articles are remarkable for solidity of surface and design. At Ferozpur, the work of an old pupil of the Mayo School of Art is skilful in execution and artistic in design. He uses the *faraih* (**Tamarix orientalis**)

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and not, as elsewhere, the shisham and poplar. His work is the best of the kind in the Province, but it is very high in price. The Hoshiarpur lacquer-work differs from that of Pakpatan in the use of metallic tin ground under transparent colour, and in addition to the scratched work of colour, figures of a mythological character are boldly painted and covered with transparent lacquer. The brilliance in colour is secured by the use of aniline dyes, which are used to effect the same object at Dera Ismail Khan and at Sahiwal. "Another peculiarity is the scratching of lines of ornament or figures in one colour of lac, and then filling the lines with another colour, the whole surface [illegible] llowed in Burma, only [illegible] wood. Rude figures of [illegible] pieces are attempted here than elsewhere. Little care is, however, taken in the selection of the wood."

Copy of letter, dated the 15th June 1896, from Dewan Tek Chand, Esq., *Assistant Commissioner, Hoshiarpur, to the Deputy Commissioner, Hoshiarpur.*

337. With reference to the enquiries made in the letter of Dr. George Watt, Reporter on Economic Products to the Government of India, dated Calcutta, the 21st February 1896, I have collected the following [illegible]

in Dr. Watt's letter.

338 "I [illegible] here in makin[illegible] coloured with [illegible]

done on white '*tahli.*'

Timbers.

339. "*Timbers used for Bobbins, etc.*—I do not exactly understand what is meant by a bobbin.* The nearest approximation I can get here is either a shuttle or a spool for winding cotton yarn upon. As regards spools, almost any wood may be used. [illegible]

Shuttles.

of *kahu*. It may be noticed that they are not coloured at all, at least the coloured shuttles are not used in this district.

"II. I send two specimens of '*tahli*' marked 3 and 4: 3 is a piece of white and 4 of black '*tahli.*' 3 and 4 are really parts of the

[illegible]

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same wood, 3 being the exterior and 4 the interior portion In order to illustrate it I send a round piece 5 which shows both conditions.

Spools.

341. "III. *Spools.*—I furnish three samples in illustration of the manufacture of a coloured spool which is so frequently used here for winding cotton yarn on, and making it into cross skeins. They are marked 6, 7 and 8.

"6 is the crude form of a spool. The two heads are made of *diyar* (*deodar*) wood, and the stem or rod connecting them is made of bamboo Bamboo wood is often used in this subsidiary way to finish up a toy as it is not easily breakable.

[illegible] A stick [illegible] varnish. [illegible] hen on it [illegible] eaves are [illegible]

Lac leaf.

[illegible]

A quantity of lac-seed is put in a small bag which is knotted on the top and then placed in a small oven called '*tokhani.*' When it gets hot it is taken out. Meanwhile a tin-foil is placed on a frying pan which also gets warmed up on the burning coals. On this tin-foil the lac bag is slowly moved from one corner to another, the lac-dye oozes out all the time and the whole tin-foil becomes coloured with lac.

Churis or Bangles

143 (*i*) *Churis or bracelets* —"I send four specimens marked 10, 11, 12 and 13 —

"10. This is a plain bracelet made of kach or glass.

"11. Here a plain bracelet is gilded over with lac-leaf.

"12. A bracelet of the form (10) is made warm and dyed with a lac-stick, and then on the outer surface of it lac-leaves are pasted as in the case of spool 6.

"13 This bracelet is entirely made of lac, the top of it being covered over with a piece of tin-foil. The inside of this particular bracelet consists of good lac, but ordinarily only phog (*i.e.*, refuse of lac after shell-lac has been made from it) is used for the purpose.

"A specimen of *phog* is sent under cover 14.

344. "IV. *Preparation of Lac—Seed-lac* —Lac as collected from the trees is shewn under cover 15 (if it is wet, it assumes when packed in gunnies the form 16) The larger pieces of this lac are collected together, dusted and washed in plain water. They are then powdered, and the stuff is mixed with some water which after boiling in a caldron in which some *sakki* and *sajji* are also put, is allowed to get cool The whole thing is afterwards put in a vessel to the mouth of which a piece of cloth is tied which thoroughly closes it. The vessel remains stationary for a little while, after which the coloured water is made to filter through this piece of cloth, when all the water runs out some residue is left at the bottom of the vessel, which is called *lakhi.* It is from this that the lac-dye, in the proper

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sense of the term, is made Its specimen is shown under cover 16*a*, *sikhi* under 17, and *sajji* under 17*a* It may be remarked here that with 5 seers of lac the mixture used is as follows .—

1. Water . . . . 5 seers.
2. Sajji . . . . ¼th of a seer.
3. Sakki . . . . . . ⅛th of a seer.

"If lac 15 is dusted and mixed, not with plain water as before, but with water which is *Musalah-dar*, *i e.*, water boiled with *Sajji* and *Suhaga* (Borax), then the residuum is called lac-seed, for which see specimen (18)."

Chapra or Shell lac.

345. *Chapra or Shell-lac.*—"Before stating the process for making coloured lac-sticks it seems necessary to say a few words about the formation of what is technically called *Chapra*, but colloquially known as *papri*, perhaps from the turn-out resembling a *Papar*, a thin crisp cake made of pulse. The lac-seeds after they are well washed are stuffed into a cloth bag, the mouth of which is tied with a piece of string. This bag is then heated over a fire, the lac inside naturally melts and through the pores of the bag emits a kind of resinous frothy substance which is at once removed by the artisan with a scraper. This frothy substance is then laid flat on a stone and at once turns into thin plates. The refuse left in the bag is called *phog* which is already referred to, is used in making bracelets, and also sometimes by goldsmiths in filling up hollow ornaments and by turners to patch up fissures in wood used for turnery.

Influence of rain on lac.

346. *Qualities of Lac*—"I send two samples of *chapra* under covers 19 and 20. 19 is made from *hari* lac, *i.e.*, lac collected in the month of *Har* (June-July) 20 is extracted from *katik* lac collected in October-November. The latter is darker in hue owing to, it is said, the mixture of rain-water with lac-germs in the rainy season.

347. "Sometimes before making the shell-lac the artisans mix some *biroja* (21), rosin of **Pinus longifolia**, with the lac-seed The reason for this mixture they give is, that the shell-lac gets more suitable for *light* colouring The price of this what may be called 'impure' shell-lac is lower than that of the pure article, and it is not unlikely that the *biroja* is mixed to increase the weight without damaging its properties to any very appreciable extent. Specimen of this 'impure' shell-lac is given under cover (22).

348. *Lac-sticks or Battis.*—"They are made from *chapra* and not from *lakhi*. *Lakhi* (dye 16 *a*) is not used in making these sticks excepting No. 37, in the formation of which both *chapra* and *lakhi* are used.

Manufacture of Battis.

349. "The process of making a coloured lac-stick may now be briefly described. Three or four *chapras* are joined together and brought near live coals placed in an oven, where they soon begin to soften. The artisan pulls the softened material like a wire with his right hand, the left hand holding a stick on which the wire is wound and unwound during the process It is then well beaten and made into a ball (specimen 23) When its colour becomes deep yellow, the piece is then removed from near the *tokhani* (oven) and placed on a small wooden-stand made fast to the ground in order to receive a good

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hammering. The ball is then made flat, the sides are raised so as to leave a depression in the centre in which a variety of colour-substances are placed according to what colour the lac-stick is intended to bear. The whole is afterwards thoroughly beaten up by a hammer until the colour-substance gets well mixed up with the *chapra*. The artisan stretches this mixture, makes it into a kind of round pencil with the palm of his hand and then flattens it into the ordinary shape of a lac-stick with his fingers.

"I send specimens of 14 coloured lac-sticks, but they are to be considered by no means exhaustive. The process is the same in the formation of each of the sticks—the material mixed with the shell-lac being ordinary colour [illegible]
Some remarks, however,

350. 24 *Yellow*—" [illegible]
ment). As the colour of the *chapra* wire, above referred to, is already yellow, that colour is easily developed.

351. 25, 26 and 27. *Green*—" It is rather curious that in making a [illegible]

said that with any other mixture the green colour does not come out well. So that in stick 26 before putting in the green colour, some white substance (powdered sulphur in this case) is mixed instead of *hartal* as in 25 Of course it is possible to make a lac-stick with green colour alone, but it is not much used. I asked the artisan to bring me a specimen, and brought me stick 27. But even in this I discovered he had put some turmeric though only of the weight of 2 grains.

352. 28. *White*.—" The substance mixed here is powdered sulphur. In making white sticks a greater quantity of colour-substance is used than in the others, and similarly greater exertion is required in beating it and mixing it with the *chapra*. Before the final stroke of the hammer they also mix *biroza-i-chil* (*i.e.*, resin of **Pinus longifolia** 21). It is supposed to brighten the colour.

353. 29. *Black*.—" Here lamp-black is mixed with the *chapra*. The oil used is that extracted from *sarson*, a kind of mustard-seed (**Brassica dichotoma**).

[illegible] oxide
[illegible] kind
[illegible] (*i.e.*,
ground-sulphur) is also mixed.

355. 34 *Lajwardi*—" This is a very favourite colour. It is made from a combination of grou[illegible]
the bazar. The pure *jamı* [illegible]
Eugenia Ja[illegible] bolana) [illegible]

356. 36 *Chapra*.—" This is a stick made of *chapra* alone. It is not often used.

357. 37—*Lakhi*." This is the lac-dye, in the proper sense of the term and is obtained by mixing *lakhi* (16*a*) with the *chapra* (19). As mentioned above, it is only in this stick that *lakhi* is used.

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against the lathe in the manner described above, but the pressing here is not so hard and not uniform. The workman moves about his hand so skilfully that he scatters the colour wherever he chooses to do so. The red colour is thus spread out and in the blank spaces or yellow surface remains as it was before. A black stick of the specimen 29 (no thin pencils are used for black or any other colour excepting the red above noticed) is now pressed in the same skilful manner, and only fills in the small borders of the spaces left by the red stick.
not a vestig
which may
chooses to h
there is the
headings of wood-carving.

361. *(iii) Atishi work.*

"About three-fourths of the lacquer-ware in Hoshiarpur is of the third kind. It is called *atishi, i.e.*, fiery, because mild fire is constantly placed near the lathe when the work is being done, and some say because the article of this style gives a fiery glow when laid in the sun I send three specimens of this work, one finished and two others showing the preparatory stages

"*Cup* (43) exhibits five stages, which are marked on it—

a. Shows the ordinar
b. When this wood
brick-powder,
with glue and water.
c. Some tin and glue are mixed together with great labour. This mixture is then applied on *b* with a rag and the result is *c*.

"A sample of this mixture is sent under cover (47) glue and tin are also sent marked (*a*) and (*b*). It is said that the right proportion of these elements for a good mixture is 2 tolas of glue in $\frac{1}{16}$th seer of (tin).

d. The fourth stage is practically the same as *c*, only the tin has been made brighter by rubbing it with a *mohra* (a kind of shell).
e. On the tin ordinary red lac-stick is pressed against the cup and the lac-colour is produced.

Cup (44)

"This shows further developments. On the red colour (as shown above under *e*) the artisan works with a pointed iron-bar which he calls his 'pen,' with this 'pen' he engraves designs of flowers, leaves, etc. In this particular case a yellow lac-stick is then pressed against the surface of the cup with the result that the engraved parts become saturated with the yellow colour. It will be noticed that the petals of flowers on the cup are engraved or rather scratched inside. A *lajivardi* lac-stick (specimen 34) is then applied to the cup and the *lajivardi* colour adheres to these engraved places alone, and the result is shown in cup (45).

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Cup (45).

"The inside of the leaves is now engraved and green colour put in with the green lac-stick. The process may be repeated and other colours put on as one desires

"It may be added that after the application of a fresh colour, *pipa* is rubbed over the surface of the cup to give it a polish. When the article is finished some mustard oil is also applied with a piece of rag in order to give it lustre and brightness.

362. (*iv*) *Naqshi work.*

"This work of pure engraving is not much in requisition here. It requires greater exertion and much more skill than the other three kinds mentioned above and owing to its comparative costliness is not much patronized.

"For specimen of this work I send one highly finished box (48) to be shown in the Museum. It is by no means the best that could be made here, as the artisan in this case (by name Jani) has been rather hurried on, as he had also to make the lac-sticks described above.

Yellow or white, red, green and black.

"These layers on the box (41) have been opened a bit to show the different colours used.

he works in the day or at night, as was the case in the preparation of box (48). In the centre of the lid there is a knob of ivory which gives the box a pleasing look."

II.—OTHER LAC MANUFACTURES.

363. There are several special industries in addition to turnery, where lac is extensively utilised. These have been incidentally mentioned in the opening remarks of this chapter but it may be desirable to deal more fully with one or two of these:—

364. ***Churis or Bracelets.***—These are made mainly from the inferior qualities of lac, such as the *khud* or dust obtained on reducing stick-lac to seed-lac; the *gaud* or fine powder derived from the washings of seed-lac; and lastly the *kiri* or *phog*—the refuse

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obtained after the shellac, button-lac, etc., has been squeezed from the melting bags These three products have to some extent separate properties and find distinct markets; but they may be dealt with in the present instance as if identical. The manufacturers of *churis* as a rule mix the *khud, gaud* or *phog* with one-third soft red clay and heat the clay and lac in a pot until they get completely mixed. From this they manufacture *churis* using a purer quality of lac to carry the colours and surface dressings. As the process differs considerably in the various provinces of India, the following passages will be found specially interesting:—

Bengal (Cuttack).

Passages taken from the Report on the Agriculture of the District of Cuttack, by Mr. N. N Banerjee, *on the subject of Lac, page 173.*

365. The principal material of which *churis* are made is *jow* or lac. To three parts of dry lac, one of red earth of the fields is added, and both are put into a *handi*, or earthen pot, and set on the fire, and the mixture is constantly stirred with a stick until it becomes of the consistency of paste. The melted matter being well mixed, is then poured out on a flat wooden board, and when it has cooled a little, it is rolled with a wooden mallet into a stick. This stick or cylinder of prepared lac is then held up over a fire of coals kept for purpose in an earthen pan (*chhelua*), and as it softens by the heat, it is again rolled backwards and forwards on the board and reduced to the thickness of an ordinary wooden pencil. Pieces of the required size are then cut off from this thin stick of lac, and each piece is held up over the fire and the two ends of it are joined. This is then set on a conical framework of wood, seven to eight inches long, tapering from three inches in diameter at the base to two inches at the apex. To the centre of the cone is attached a cylindrical handle about 16 inches in length, which is held in the hand while the upper frame-work is made to revolve over the fire. The *churi* is thus moulded into shape, and is smoothed with the blade of a knife. When it cools and turns hard, it is taken out and another piece of lac is taken up and the process is repeated When five or six are ready, they are again put on the frame and held over the fire, and when they have softened a little, the first [illegible] diate ones [illegible] coloured [illegible] ch *churi;* [illegible] shed with [illegible] detached [illegible] edges of each *churi*, and small bits of glass are set round the middle. The first and the last *churis* are covered over with *panni* or *ránga* (tinsel) to resemble silver. The *churis* are then ready for use. Coloured lac used for the coating is prepared in the following manner:—

Colours.

366. To three parts of lac, one of *hartal* is added to make the colour yellow. For a red colour one part *hinglu* (country vermilion)

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is added to three parts of lac, and for a blue colour one part of indigo is added to three parts of lac. Half of *hartal* and half of indigo [illegible] matter [illegible] to the [illegible] while the lac with which it is to be mixed having been placed in a piece of [illegible] it becomes so liquefied that it can [illegible] n it is held over the stone containing [illegible] to fall out in drops on the paint. The whole is then mixed with two sticks, and becomes coloured lac, and is wrapped round a stick and allowed to harden In this way it is kept ready for use.

Coloured lac thread, referred to above, is made by drawing coloured melted lac into thread with a stick This thread is put on the *churi* round the edges and represents a raised border.

Passage taken from the Hand book of the Manufactures and Arts of the Panjab, by B. H Baden-Powell, Esq, *1872, page 242*

Panjab.

367. Lac bracelets or churis "are made in many places, especially Delhi, and the process in the Panjab exactly resembles that described in a report on one of the Central Indian Districts, which I have unfortunately mislaid, but which I have used for the purpose of quoting the recipe for making the gold solution that gives the gold lustre to these pretty but fragile toys.

368. "Refined or purified lac is mixed with the fine powder of burnt bricks, and the two are heated together in an iron pan and stirred till perfectly combined. The lac is drawn out into sticks of the thickness of the intended bracelet, and this is done by rolling the sticks on a flat board while still hot. Pieces of the requisite length are cut off and each piece is bent round and joined, and placed on a wooden cylinder to cool, and to be further ornamented The glazing with gold solution and silvering is generally done before the sticks are cut up.

The Dewan of Jhallawar in a highly instructive note on the Lac Industry of that State remarks regarding the Churi trade:—

369. "The lac is most commonly used in Jhallawar in making *churis* (bangles for females) The material used for this purpose is prepared by mixing together equal quantities of lac and sand. At first it is made into thin sticks, or pencils of suitable lengths which are rounded off by being rolled between a smooth bat-like piece of wood and slab of stone, and are then made into the required shapes by somewhat similar process. The *churis* thus made are subsequently [illegible] Sometimes [illegible] leaves are

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Extract from a communication received from the Prime Minister of Bandi State, No 201 of the 16th February 1897:—

37 . "Bangles for wom n are also made of *chapri* with a mixture of li le turpentine in it *Chapri* is a preparation of lac, and is imported fro n abroad Four se s of bangles are supplied as a sample, as also six piec s of *chapri* which comes from Bombay raw, and is dyed locally, and five *chapri* marbles and five cubes locally made up of *chapri*."

The use of turpentine may be remarked to be the chief point of interest in this passage.

The following account regarding the manufacture of lac bracelets is taken from the Bombay Gazetteer, Vol. III (Karia and Panch Mahals), pages 249-50:—

Bombay (Karia and Panch Mahals).

371. "Before being used the powdered lac, *kanja*, is placed in a bamboo basket, mixed with powdered alum, washed with water, and for a day set to dry in the sun. Then it is ground to powder, melted in a metal pan, and in the proportion of two ounces to the pound (five *tolas* to one *seer*) mixed with brick dust and old powdered lac bracelets. The mixture is melted, poured on the ground, and rolled into a round flat cake The cake is cut into three or four pieces, each piece heated and between two stones rolled into a stick, generally 5¼ pounds in weight. The stick ready, some dearer lac is mixed with yellow orpiment, or red earth, or both, and made into small cakes from five to six ounces in weight. Then these yellow or red cakes are laid as an outside coating on the first lac-stick, in such a way as to make it all red or all yellow, or one side red and the other yellow. The end of the stick is then heated, drawn out, and then the proper length for a bracelet cut off As they are formed, the bracelets are slipped over the oily conical head of a pestle-shaped tool known as the rice-pounder, *sameta*. This has usually a head about ten inches long, varying in size from two inches across the top to four inches across the foot, and a handle about a foot and a half long. When the head has been

with a mixture of gumarine, *chandrus*, and linseed oil, and coloured vermilion, blue, or yellow.

372. "Whe[illegible]
step is to print
of tin, *kathir*, a
of glue The
mered by two men, the particles mixing together till they form a dull-grey metallic plate Next day the plate is broken into pieces thrown into a copper vessel with a little water in it, and placed over a slow fire The plate gradually melts leaving a sediment sometimes strained off through a coarse cloth. The water is now ready for use. Meanwhile a little very fine cotton wool is tightly wound round a small bamboo chip and so wetted and pressed that it makes a pad or

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stamp hard enough to have a pattern graven on its face by a large iron needle. This cotton stamp is now taken, dipped in the tin-water, being very lightly pressed on the cylinder of bracelets, prints its pattern on their varnish After printing the bracelet the cylinder is varnished once a day for three days, the varnish turning the white markings of the tin pattern into a beautiful gold. Then the pattern is completed by studding the bracelet with drops of tin-water coloured red with vermilion or white with chalk A final coating of varnish finishes the work When they are to be sold the bangles are separated from each other by a knife-like tool Each bangle is then cut, passed over the wearer's hand, and the end melted and joined The bracelets are [illegible] each han[illegible] and by [illegible]

373. "These lac bracelets are an imitation of the costly ivory Ratlam bracelets, of which a woman generally gets one set at her marriage, wearing them only on very great occasions Besides bracelets, yellow and red striped armlets, *golás*, are worn between the elbow and the shoulder. Except that they have neither varnish nor pattern, these are made in the same way as the bracelets Two of them sell for ⅜*d.* (a *pice*). The manufacture of lac bracelets gives employment to a special class of craftsmen called Lákhárás Of these six families are settled at Jhalod and nine at Dohad. About half of them are Musalmans and half Hindus "

Bombay.

The following further passage from the Bombay Gazetteer (Nasik), Vol XVI, page 180, may be regarded as instructive

374 "Lac working gives employment to a small number of Musalmans who form a separate community, known as Lakháris They are [illegible] and Chandor The raw material is [illegible] or native stationers, who get it from [illegible] ure other pigments, vermilion, orpiment, indigo, and copper leaf, which also they get from the Bohoris. The process is to mix a certain amount of cheap sealing wax with brick-dust, and heat it till it becomes thoroughly pliable It is then made into a stick, about an inch in diameter, and from one to two feet long Next it is covered at one end with a layer of lac coloured red, yellow, green, or blue, by mixing with it mechanically such pigments as vermilion, orpiment, and indigo, or if green is wanted, a mixture of orpiment and indigo The end thus covered with coloured lac is then heated and drawn out. When the coloured end becomes as small as a quill, it is cut away from the stick, and, while still hot, it is stamped by a carved brass or wooden mould. It is next wound round a wooden cylinder and the ends heated and joined, and, finally, to make it lie in one plane, it is laid on a stone slab, covered with a flat piece of wood, and struck lightly with a hammer

Tools.

375. "The lac-worker uses six tools The rolling pin, *satla*, to roll the heated lac into a stick, worth 6*d* (4 *annas*) A stone, which must be flat and is generally a piece of a broken grinding mill. The stone is heated and the lac softened on it and rolled into a stick. The cost

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is nominal. A hammer worth 6*d*. (*annas*. 4). Two *thasás* or many-sided wooden or brass moulds with different designs carved on each face, each mould costing from 16*s*. to £1 (R8—R10). The *sácha* or wooden cylinder, round which the wax is wound to give it the shape of a ring. The *tháppa*, or flat piece of wood, with which the lac ring is pressed to make it lie in one place.

376 "The only articles made are lac bracelets. The maker generally disposes of them to the Kásárs, or bangle-sellers, selling them at from ¾*d*. to 1½*d*. (½—1 *anna*) each. They are worn by Hindu women of all classes. Nasik lac bracelets have no special merit, and are not in much demand. The workmen are poor, even with the help of their women, they do not earn more than from 8*s*. to 12*s*. (R4—R6) a month."

MANUFACTURE OF VARNISH.

377. *Varnish.*—Lac may be said to be one of the most extensively used ingredients in the so-called "spirit varnishes"; but in order to give tenacity and elasticity to these some of the softer resins, such as elemi, mastic, Canada balsam or Venice turpentine, are indispensable ingredients. The spirit evaporates and a fine coating of lac and resin is left behind which constitutes the polish or varnish. This is, however, when lac only is used, liable to crack on exposure to the air. It is probably from a similar reason that in the better class lac-turnery, the finishing polish is given with an oil, such as linseed or sesamum. The "oil varnishes" differ from the spirit varnishes mainly by the fact that they dry through a chemical change taking place in the oil which oxidised into a tough glossy film.

378. As already stated (paragraph 1), reference is made in the Ain-i-Akbari (1590 A D.) to the lac-varnish to be used on houses and furniture. The knowledge in this substance is, therefore, by no means a modern one with the people of India. In Europe and America lac-varnishes are often coloured and in that condition are extensively used for metal-work, for imitation gilding and bronzing and for staining timbers. Lac dissolved in alcohol and coloured with gum-gutta or saffron, etc., may be used as a varnish to impart a gold appearance to metals while not obscuring their brightness. Mr. Baden Powell in his Panjab Products appears to have been one of the earliest Indian authors to draw attention to the gold-coloured varnishes used in this country. His account has been republished by various writers and the story told in different language, but the facts remain the same. The following is Mr. Baden-Powell's original passage in which he deals with the application of this art to the manufacture of *churis* (lac bracelets):—

379. "To silver the sticks, tin leaf or foil is mixed with half its weight of dry glue, and these are pounded and ground together for a

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MANUFACTURE OF VARNISH

long time, till in about six hours' time they amalgamate. The mass is then thrown into very hot water, when it crumbles into little pieces. They then stir this up and pour off the water, repeating the operation till all dirt and impurity in the water disappears. When the solution is quite pure, they boil it up and let it stand, carefully covered, for the night.

380. "Next day the silver solution is found deposited. This is spread with a brush on the lac, and burnished by rubbing over with strings of glass beads. If it is desired to produce the effect of gold, the silvered lac is painted over with a transparent yellow varnish prepared as follows:—

381. "Gum myrrh (*bol*) is boiled in sweet oil in proportion of 40 to 48. The liquid is strained through a cloth; the sediment thrown away and the oil set aside. An earthen pot is now smeared with clay on the underside, and its mouth is closed up with an earthen cover, the edges of which are luted over with clay, so as to render it air-tight. This is heated red-hot over a fire. When quite red, the mouth is opened and little bits of *sundras* (copal) are thrown in. The same weight of *sundras* as of *bol* is used; the mass is stirred and the mouth again closed. The stirring and heating are repeated till the copal is thoroughly reduced. The myrrh and oil solution is now added to it, and the whole heated and stirred, after this the mixture is strained through a cloth and is ready for use. The lac bracelets are often further ornamented by having little glass beads and bits of tin foil stuck along the edge."

Passages taken from the Cyclopædia of India and of Eastern and Southern Asia, by Surgeon-General Edward Balfour, *pages 649—651, 1885*

382. Lacquer, a varnish either for wood or for brass, made with shell-lac and spirits of wine. Hard-wood lacquer may be in the proportion of 2 lbs. of lac to the gallon. Another recipe is 1 lb. of seed-lac and 1 lb. of white rosin to a gallon of spirits of wine. For brass, the proportions are $\frac{1}{4}$ lb. of pale shell-lac to 1 gallon of spirit. It should be made without heat, but simply by agitation for five or six hours. It should then be left until the thicker portions have subsided, when the clear lacquer must be poured off, or, if not sufficiently clear, it must be filtered through paper. It darkens by exposure to light, so that paper should be pasted round the bottle to exclude it. A pale-yellow lacquer may be prepared from 1 oz. of gamboge and 2 oz. of cape aloes, powdered and mixed with 1 lb. of shell-lac. For a full yellow, $\frac{1}{4}$ lb. of turmeric and 2 oz. of gamboge, for red lacquer, $\frac{1}{4}$ lb. of dragon's blood and 1 lb. of annatto. The colour, however, is modified by that of the lac employed. Lacquers may also be coloured

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by dissolving the colouring matters in spirits of wine and adding the proper proportions of these to the pale lacquer, according to the tint required Mr. A. Ross prepared lacquer with 4 oz. of shell-lac and ½ oz of gamboge, dissolved by agitation in 24 ounces of pyro-acetic ether The clear liquor is decanted, and when required for use is mixed with eight times its volume of spirits of wine. Hard-wood [illegible]

producing a brilliant e[illegible] be dry and warm Th[illegible] the work is polished [illegible] the lacquer from adhering [illegible]

MANUFACTURE OF SEALING WAX.

3. *Sealing-wax, Lac-toys, Lac-mats, Lac-paper, Lac-dye Ink, Lac and Sand whetstones, etc.*

383 *Sealing-Wax* Mention has already been made of the fact that certain articles are manufactured entirely of lac. The most generally known example of this nature is of course sealing-wax. This is prepared from any quality of lac up to the purest shell-lac. It is mixed with rosin to lower the melting point All the poorer qualities of sealing-wax are of course made of the waste lac, such as *phog*, and they are coloured with the ordinary pigments. It is stated by Indian makers that the alizarin reds yield green sealing-wax and that the reds commonly met with have been produced with red-oxide of mercury.

384. *Variegated Coloured Marbles.*—Sir George Birdwood gives the following brief account of the manufacture of marbles, rulers, etc., of mixed colours.—

"The variegated balls and sticks are made by twisting variously coloured melted sealing-wax round and round a stick or ball from top to bottom in alternate bands. Then the stick or ball is held before the fire, and with a needle or pin short lines are every here and there drawn perpendicularly through the bands of sealing-wax, drawing the different colours into each other, when the stick or ball is rapidly rolled on a cool, smooth surface, and that intricately variegated effect is produced which is so puzzling until explained."

The same writer gives the following brief notice of the lac-mats—a speciality of South India:—

385. *Lac-Mats* —"The netted mats are made by allowing the [illegible] to cool, and then drawing [illegible]ions of three or four turns [illegible] of all sorts of variegated

colours, but chiefly scarlet and black, and black and golden yellow. I describe the process from actual observation " MANUFACTURE OF RULERS MARBLES AND MATS FROM LAC.

386. *Ink.*—In a report received from the Political Agent, Haraoti and Tonk, Deoli, No. 1664 of the 7th October 1896, mention is made of lac being used " for making fast colour ink used in writing documentary papers. It is unfortunate that full particulars have not been afforded regarding this ink, but these may doubtless be afforded at some future occasion, when enough information may have been procured to justify a future note on this subject It is believed that lac-dye is extensively employed as a red ink, and it is well known that shell-lac as an important ingredient in lithography both in India and all other parts of the world. INK FROM LAC-DYE.

387 *Lac-leaf.*—A full account of the preparation of lac-leaf will be found (p. 324) in the article contributed by the Assistant Commissioner, Hoshiarpur. Lac leaf is extensively used by the natives of India in their tinsel ornamentations. LAC LEAF.

388. *Whetstones.*—These are made in most provinces. The best quality of shellac available is melted in a pot over the fire and intimately mixed with an equal weight of the purest river sand. When intimately mixed and fussed together the molten mass is beaten into the shape and thickness of a whetstone. Similarly, a preparation of lac and sand is used to fasten sword and knife blades into the hafts. The turner also employs hardened lac as a temporary means of fastening articles to be turned on the lathe. WHETSTONES FROM LAC AND SAND.

389 *Blow-pipes* —Mr H Z Darrah, formerly Director, Department of Agriculture, Assam, wrote — LAC COATED BAMBOO BLOW-PIPES.

"This is a curious article made by one Muhammadan of Sylhet. The pipe is of bamboo and lacquered with effective colours. The arrows, 100 of which are sold with each pipe for R3-2-?, are made of small strips of bamboo, 8 or 9 inches long, tipped with iron and winged with an inverted cone of paper"—*Reports on Artware of India (1885)*.

PIGMENTS USED IN LAC-TURNERY.

PIGMENTS USED IN LAC-TURNERY.

390 The following series of jottings compiled province by province, gives the chief facts known regarding the tinctorial reagents used in India along with lac.

391. *Assam.*—" *Composition of lacquer colours* —The art of manufacturing lac-wares seems to be dying out in Assam Sibsagar and Assam.

PIGMENTS USED IN LAC TURNERY.

Sylhet are the only two districts where the art is still practised. In Sibsagar the following colours are used. They are prepared by mixing shellac with the substances noted against them, respectively :- (1) yellow with orpiment, (2) red with vermilion, (3) blue with indigo, and (4) black with lamp-black fine charcoal obtained by burning the dry shell of a bottle-gourd (*Lagenaria vulgaris*). In Sylhet, a larger assortment of colours is in use. These are :—(1) sky blue (*asmani*) obtained by mixing powdered indigo and sulphur with shellac, (2) red by mixing lac with vermilion, (3) violet, with violet powder, (4) grey, with white lead, (5) brick red, with red resin, (6) orange with vermilion and orpiment, (7) dark green, with green powder, (8) green *with indigo and orpiment, (9) black, with lamp black, and (10)* yellow, with orpiment. The violet and green powders are presumably imported and of mineral origin. It is not known what red resin is."

N.-W. P. and Oudh.

392. ***North-West Provinces and Oudh.***—From Agra (letter No. 3630, dated 6th June 18 6) the following extracts may be given of the pigments used in that district :—

Quantity of lac used.	Articles mixed for producing colours.	Proportion of colour sed to one seer of lac.	Colours produced	How lac and colouring substances are mixed.
(1) One seer	Vermilion or Shingraf	½ of a seer	Red.	By melting 1 and 2 together.
(2) Do.	Orpiment or Hartal	do	Yellow.	
(3) Do	Indigo or Nil and sometimes charcoal of Babul tree	do.	Black.	
(4) Do	Indigo or Nil and orpiment or Hartal in equal parts.	do	Green.	By slightly melting the lac and beating it with a stone hammer on a piece of stone spread over with the colouring substance of the required colour.
(5) Do.	Indigo or Nil and white-lead or safeda.	do	Light indigo and if safeda is not mixed deep indigo	
(6) Do.	Gulal, the red mixed powder used during the Holi ceremonies and obtained from Benares.	do.	Gulali or *Scarlet.*	

PIGMENTS USED IN LAC-TURNERY.

393. ***Panjab.***—The following passages may be given under this heading:—

Panjab.

394. ***Shahpur.***—The lacquered wood turnery of Sahiwal differs from that of other places in being more crude in colour and simpler in execution. A particularly unpleasant aniline mauve is used; but there is a better class of vases, platters and toys made in two colours, red and black, or red and yellow, or black with either. The scratched patterns are bolder and larger than elsewhere and many toys, *e.g.*, children's tea-sets, are finished in transparent lac only, the colour and grain of the wood showing through. Chess-boards with chess-men and a large variety of toys of forms that might puzzle an English child, are made at very cheap rates, but they do not seem to be as popularly known as they deserve to be.—(*Panjab Gazetteer, Shahpur District, 1897, page 188*.)

395. An exceedingly interesting report regarding the district of I[illegible] was found impossible t[illegible] the chapters of this r[illegible], used in that district should therefore be read (p. 320) in this connection.

Report on manufacture of Wooden toys, etc., furnished by the Deputy Commissioner, Dera Ghazi Khan, Panjab, with letter No. 580 L. F., dated 16th December 1896.

396. "Toys, circular boxes and other such articles prepared by artisans of the Jampur and Dera Ghazi Khan Tehsils in this district are generally made of *shisham* wood (Dalbergia Sissoo). Large and small blocks of *shisham* are kept ready for use; and after removing the [illegible]

[illegible]

same, *viz.*, bits of plain or tinted lac are attached or stuck on to a straight piece of wood with which the coatings are turn by turn given, while the article is once more being whirled in the lathe. Some of the articles are finished by removing the colour in parts and filling the gaps with an amalgam of mercury and tin, or are carved to insert bits of ivory of different shapes."

Extract from letter No. 938, dated the 24th December 1896, from the Deputy Commissioner, Shahpur, Panjab.

397. "Colour sticks are used by wood-turners to colour their ware when the turning process is finished. The sticks are made of shell-lac

PIGMENTS USED IN LAC-TURNERY.

melted down and coloured by various simple and compound colours as described below, or they are made of shell-lac mixed with pounded aniline colours imported from Europe.—

(*a*) Yellow—Is prepared by mixing melted lac in the proportion of $2\frac{1}{2}$ chittacks to $1\frac{1}{2}$ chittacks of orpiment (Sulphide of arsenic)

(*b*) Green—Is prepared by mixing $\frac{1}{4}$ chittack common oil to the yellow colour as above described.

(*c*) Red—Is prepared by mixing 3 chittacks lac with 1 chittack of sulphide of mercury.

(*d*) White—Is prepared by mixing one chittack shell-lac with $1\frac{1}{2}$ chittacks of white lead (carbonate of lead).

(*e*) Black—Is prepared by mixing lamp-black with lac.

(*f*) Sharbati or lac colour—Is made by mixing a quantity of shell-lac with *baroza* (= rosin of Pinus longifolia)."

Rajputana.

398. *Rajputana.*—Rao Bahadur P. Sukdeo Prashad, Judicial Secretary to the Masahib Ala of Marwar, in a long and interesting report on every aspect of the lac trade and industries of that State, furnishes the following particulars regarding the pigments employed:—

"Before the introduction of European pigments (aniline) only fast colours made of country materials were used, but now this is not the case. The ordinary aniline colours sold in the bazars are mixed with the lac and used It is a fact that the new colours are very deep and are generally liked by the public

"The following pigments are commonly used:—

No. 1.—Lac called *chapri*.

No. 2.—*Hartal* orpiment

No. 3.—Broken bangles of lac (lac and sand mixed, called *aster*, or the inner layer of colour 1 tola lac heated mixed with 5 tolas of sand make these bangles).

No. 4.—Lamp-black.

(= new red colour).

new green colour).

No. 9.—*Sasui* (molet), a bluish colour."

399. "The following combinations of these form the battis of coloured lac-sticks used by the turners:—

"No. I *Shingraf* stick or *batti*—8 tolas of lac are heated on charcoal fire for 15 minutes, half of which is made in the form of a

water

whole is

with 1

ter this

PIGMENTS USED IN LAC-TURNERY.

another 1 tola of lac is mixed, heated and beaten. *Water is not used* in mixing.

"No. III Green stick—It is made of yellow (*without water*) No. II and the green colour (*Naya rang*) as to proportions, when the yellow colour is prepared half of it is kept and only ¼ ratti of green is mixed with it.

"No. IV Black stick—2 tolas lac and half tola of *Bahu-ka-guli* (No. 6) with *water* are mixed and are heated on fire and beaten. No. 2 (*a*) Yellow (with water) 6 tolas *hartal* were ground with water and mixed with 12 tolas of heated lac.

"No III(*a*)—Green stick (*with water*) half of the No. II (*a*) is mixed with green colour and is heated on fire and beaten.

"No. V Red stick—One tola colour *with water* is mixed with 8 tolas of lac and heated on fire till the required colour is obtained

"No. VI Violet stick—6 tolas of lac are mixed with half tola of sosni colour with *water* and is heated on fire.

"No. VII Astar stick—8 tolas of bangles No 3 and 6 tolas of lac are mixed and heated on fire. No IV (*a*), Black 4 tolas of lac and ½ tola of lamp-black and heated on fire.

"No. VIII stick—Lac only heated.

"No II. (*a*) Yellow (*with water*) is used as a first layer of colour except in the case of very smooth surfaced wood.

Alternate use of water battis with others.

"No. VII. *Astar* (lac and bangles of lac) is used as second layer.

"All other colours are done after these two layers have been finished. In order to equalize the colour, the fruit stalk of palm tree is rubbed against the wood on the revolving lathe and the leaf blade is similarly used in the case of fine lines only. The finishing touch is given by *til*

400. Babu Durga Pershad Hakim furnished an instructive note on the Lac Industry of Indergarh in the Kotah State, Rajputana. The following passage may be here given from which it will be seen that aniline dyes are now-a-days most unfortunately being largely employed in the production of the highly artistic art-turnery for which that town is famous:—

401. "The following are the pigments used in preparing the coloured lac sticks used by the turners:—

1. Lac, uncoloured (heated and unheated). 2. "*Safeda*" (heated and unheated) known locally as white lac of European manufacture. This cannot be prepared locally; sticks of it are purchased at Indergarh for 5 or 6 annas a piece; 3. "*Neel*" (indigo); 4. "*Baigni*" (aniline purple of European manufacture); 5. "*Gulabi*" (aniline rose of European manufacture); 6. "*Hara*" (aniline green of European manufacture); 7. "*Hingloo*" (vermilion); 8. "*Hartal*" (orpiment); 9. "*Kajal*" (lamp-black).

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"All the above are obtainable in any Indian bazar, and the coloured sticks are prepared by the artisan himself by mixing them with heated pure shell-lac or white lac in the following preparations :—

> 10. Yellow—Shell-lac and *hartal*, 11. Black—Shell lac and *kajil*; 12. Blue-black—Shell-lac and indigo; 13. Red—Shell lac and vermilion; 14. Purple—White lac and European purple, 15. Rosy—White lac and European rose colour; 16. Sky blue—White lac and indigo; 17. Dark green—Shell-lac, indigo and *hartal*; 18. Green—Shell-lac and European green (aniline).

"The ingredients are apportioned according as to whether the colour required is to be light or dark. Of late years, European colours have been imported owing to their cheapness; they are supplanting the colours locally produced and are everywhere obtainable.

"There are only four artisans at Indergarh and they content themselves with making sufficient for their daily needs. No stock of lac wood-work is kept, and there is no export trade. With a demand for export this trade would develop."

Bombay and Sind.

402. ***Bombay and Sind.***—The Collector of Haidrabad, Sind, in his letter No. 3325, dated 23rd July 1896, furnishes the following particulars regarding the pigments used by the lac-turners of that district:—

"The ingredients for colouring, etc, generally used in the manufacture besides lac are orpiment, vermilion, indigo, *dhup*, a preparation of resin, brimstone, and a green paint imported from Europe. A small quantity of each of these ingredients is sent herewith, together with a stick of uncoloured lac, as well as a few sticks of coloured lac illustrating each colour used in the industry. Coloured lac is made by mixing the colouring ingredient which is first reduced to powder with plain lac and heating the mixture over fire. Lac mixed with orpiment in the above manner produces a yellow, when mixed with vermilion it produces red, and so on. The green colour inside and underneath the box is done by hand."

Madras.

403. ***Madras.***—The following information has been communicated by Mr. Edgar Thurston, Superintendent of the Government Museum, under cover of his letter of the 7th April 1896:—

"A small quantity of sample uncoloured lac is taken. Dust, etc., removed from it. Then a small quantity of sample C (*Nattu arithalam*)* is taken and very finely powdered, a little water is then added to it and mixed so as to get a thick consistence. Then fire

*This from the description would appear to be yellow arsenic = orpiment.—G. WATT.

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is kindled with charcoal in a broad-mouthed chatty in the way gold-smiths do for their work. Then the lac is melted. This is done in the following way:—In a stick a little of the lac (*areul arrakku*) is touched and held before fire This begins to melt and becomes adhesive. Then a little more of the lac is dipped in it and held

all the lac has been melted. Then these sticks are dipped in the colour which has been prepared of sample C (*Nattu arithalam*) little by little, and by holding before fire the lac and the colour are well mixed while melting by rubbing the sticks one over the other. When it has been mixed well and while hot the coloured lac is removed from the sticks and made into a round mass and shaped into sticks like sealing wax. After a little while it becomes hard

"Red, green and blue coloured lac are made in the same way as above described. Sample D being used for red, sample E mixed with a little of sample C for green and F for blue colours."

404. Process for manufacturing of coloured toys—

"The wood that is to be turned is cut into log and fixed in the lathe. This is simply two long pieces of wood, to each of which a sharp-pointed iron is fixed to hold the wood that is to be turned between. When the wood has been fixed it is made to revolve by passing round it at one end of a string which is tied to a bamboo in the shape of an arch like a bow While the wood is revolving the chisel is applied to its surface in whatever way the wood is to be turned. The chisel scrapes the wood to the shape required, and before removing the article from the turning machine, sticks of coloured lac are pressed against its surface as it revolves The friction melts the lac which adheres to the surface in an unpolished stage Then a leaf, called *Thalanalai* (sample B) in Tamil, is pressed against the coloured surface. This gives polish to the colour."

TIMBERS USED IN LAC-TURNERY.

TIMBERS USED IN LAC-TURNERY.

405. As already explained, one of the objects of the enquiry into the subject of lac-turnery was to discover the timbers used for that purpose, from the idea that these might also be found suited for the production of bobbins. The numerous cotton, jute and wool mills that are scattered all over India have to import enormous qualities of bobbins annually. A correspondent (on his being asked for information as to the Indian timbers suitable for bobbins) remarked that he had ascertained in Madras that bobbins of a certain size were regularly procurable at the ridiculously low price of R24 per gross; he was accordingly of opinion that it could not pay to compete. But

TIMBERS USED IN LAC-TURNERY.

if it pays an importer to dispose of bobbins at the price or any other price, the opinion generally held is that it should still more pay a maker to produce them in India, provided he can obtain suitable timber in sufficient abundance and at a remunerative price. This view of the case has at all events been entertained by at least three separate merchants who have each affirmed that they are willing to import the self-same machinery as used in the bobbin trade of Europe and to start factories on a large scale, provided they can get satisfactory evidence as to the one difficulty—the timber supply. The observations recorded in this paragraph, it is hoped, may, therefore, prove of some value to those interested in the bobbin trade as well as to those solely concerned with lac-turnery.

406. The following alphabetical enumeration has been framed from all the replies to hand during the past four years—the passages dealing with this subject having accordingly been omitted from the letters quoted in other chapters of the review It is believed, however, that this mutilation will not materially lessen the value of the contributions that have been received, seeing that the list that follows gives the names of the chief localities where the timbers in question have been recorded as used in lac-turnery.

407. I would, however, here explain that in only rare instances were botanical specimens furnished along with the letters or samples of woods received I have had accordingly to accept the names (scientific or vernacular) given me as correct or to arrive at these from comparison of the timbers contributed with those already in the Museum. In this connection I would, for example, mention *Khirni*, *Khirini* or *Khirna*, one of the most widely used of all timbers. In some instances the samples to hand have borne one or other of these vernacular names accompanied with **Wrightia tinctoria, Mimusops indica,** and **M. Kauki** as the corresponding scientific name. I believe that most, if not all, the timbers in question are **Wrightia tinctoria,** but I have preferred to give the other scientific names as well because of their having been specially mentioned:—

Acacia arabica, *Willd.* (Leguminosæ), the *Kikar* or *babul* of Hoshiarpur, Shahpur, etc. In Jaipur it is especially mentioned as suitable for Indian clubs—*Mugdars.*

A. Catechu, *Willd.*, the *Hair* of Hoshiarpur; Jaipur mentions it as used for the feet of *charpoys* and *musals.*

A. modesta, *Wall.* the *Phulah* of Hoshiarpur.

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Adina cordifolia, *Hook. f.* (Rubiaceæ), the *Haldu* of Saharanpur; the *Aladran* of Surat where it is said to be largely used for cradles (*palnas*), etc.

Ailanthus excelsa, *Roxb.* (Simarubaceæ), used in Jaipur for scabbards, etc.

Albizzia Lebbek, *Benth.* (Leguminosæ) the *Shrin* of Shahpur.

Anogeissus latifolia, *Wall.* (Combretaceæ), the *Dhau* of Marwar.

Artocarpus Chaplasha, *Roxb.* (Urticaceæ), the *Sam* of Assam.

A. integrifolia, *Linn. f*, the Jack-fruit trees, Assam.

Anthocephalus Cadamba, *Miq* (Rubiaceæ), the Kadan is in Alwar used for toys, bottles, jugs, etc.

Bauhinia latifolia (Leguminosæ), the Jinja of Marwar.

Bombax malabaricum, *DC.* (Malvaceæ), the *Semul* is in Ulwar used for boxes, packing cases, toys, scabbards, fishing floats, linings of well, etc.

Borassus flabellifer, *Linn.* (Palmæ), the *Tala* or Arna according to Dr. Hendley is in Jaipur used to make painted animals It is a soft and weak wood but can be worked easily.

Boswellia thurifera, *Roxb* (Burseraceæ), is the *Salar* wood of Jaipur is especially used in making *hooka* pipes or *nechas.*

Cassia Fistula, *Linn*, (Leguminosæ), the *Sonaru* of Assam.

Cedrela Toona, *Roxb.* (Meliaceæ), the *Tun* of Saharanpur, Hoshiarpur, Dera Ghazi Khan and Shahpur.

Cordia Myxa, *Linn.* (Boraginaceæ), is in Jaipur known as *Gondi* and it is said to be used for *hooka* shafts

C. Rothii, *R. & S*, the Gundi of Marwar.

Dalbergia Sissoo, *Roxb* (Leguminosæ) the *Shishan* of Saharanpur, the *Tahli* of Hoshiarpur is mentioned in connection with Jaipur as good for opium boxes, charpoy legs, chilums and *sulphis* (datura-flower-shaped chilums). In Ulwar it is stated this wood is used for all sorts of furniture and turnery

Eugenia Jambolana, *Lam* (Myrtaceæ), *Jamun* wood is in Jaipur mostly used for *nechas* or smoking pipes, *Chilum-ki-nalis* (tobacco pipe-stems).

Gmelina arborea, *Linn.* (Verbenaceæ), the *Kumber* or *Kunbher* of Ulwar. Is used for making *saringis* (musical instruments) cups, toys, furniture, pannels of carriage doors and all kinds of ornamental work. It takes paint, polish and lac readily.

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Holarrhena antidysenterica, *Wall.* (Apocynaceæ), the *Kura* of Saharanpur; the *Veppalai* supposed to be used in Vellore, North Arcot, for lac turnery.

Jasminum grandiflorum, *Linn.* (Oleaceæ), the *Chameli*-wood of Jaipur is good for toys, but too soft for charpoy legs.

Lagerstrœmia Flos-reginæ, *Retz.* (Lythraceæ), the *Ajur* of Assam.

Mangifera indica, *Linn.* (Anacardiaceæ), the mango is largely used in Agra; occasionally in Hoshiarpur, is only rarely used in Jaipur.

Melia Azedarach, *Linn.* (Meliaceæ), the *Drek* of Hoshiarpur.

Mesua ferrea, *Linn.* (Guttiferæ), the *Nohar* of Assam.

Millingtonia hortensis, *Linn. F.* (Bignoniaceæ), the *Akas nim* of Saharanpur.

Mimusops indica, *Kurz* (Sapotaceæ) the *Khirni* of Indergarh in Kohat State, Rajputana

M. Kauki, *Linn.*, is said to be the *Khirni* of Shahpura in Rajputana, where it is said to be imported from Jaipur and Gwalior.

Morus indica, *Linn.* (Urticaceæ), the *Shahtut* is in Jaipur used for making *Dunkas* and snuff boxes.

Olea cuspidata, *Wall.* (Oleaceæ), the *Kan* of Shahpur.

Pinus longifolia, *Roxb.* (Coniferæ), the *Chil* of Hoshiarpur.

Populus euphratica, *Oliv.* (Salicaceæ), the *Bhan* of Shahpur; this is the *Bahan* of Haidrabad, Sind, where it is extensively used and much appreciated for turnery owing to its taking colour easily; it is a common tree in Sind especially on river banks.

Psidium Guyava, *Linn.* (Myrtaceæ), the Guava is according to a letter received from Mr. E. Thurston, used in Vellore, in North Arcot for lac-turnery.

Stephegyne parviflora, *Korth.* (Rubiaceæ), the *Kain* of Saharanpur.

Sterculia urens, *Roxb.* (Sterculiaceæ), the *Kadhu* of Ulwar. Sitars (*Guitars*) and toys are made of it.

Tamarix orientalis, *Forsk.* (Tamaricaceæ), the *Farash* of Agra, the *Ekean* of Shahpur, Pharwan of Ferozpur; the *Lye* of Haidrabad, Sind, is used for walking sticks, rulers and turnery.

Tecoma undulata, *G. Don* (Bignoniaceæ), the *Rohira* of Marwar or *Roira* of Jaipur, used for charpoy legs, tobacco boxes, etc. In Ulwar this is the *Rohera* and it is said to be useful for toys, agricultural implements and furniture; it takes a beautiful polish.

C. 1491-1511.

TIMBERS USED IN LAC-TURNERY.

Tectona grandis, *Linn. f.* (Verbenaceæ), the Teak wood or *Saguan* of Marwar (rarely used), but largely in Khandesh District of Bombay.

Ulmus integrifolia, *Roxb.* (Urticaceæ), the *Kanaj* of Marwar; the *Chhilal* of Jaipur (largely used for the *chalpat*, rattle, the *phirkness*, top, and the *chakis* or humming tops).

Wrightia tinctoria, *R. Br.* (Apocynaceæ), the *Dudhi* of Saharanpur; the *Khirini* or *Khirni* of Marwar, of Indergarh, of Tonk, of Udaipur, of Jaipur; *Kherna Sirohi*, W. Rajputana; *Anni* or *Dudi* of Dholpur.

408. Mr. T. H. Storey of Udaipur, Rajputana, who furnished a botanical specimen, and says "this tree abounds in milky juice. Its wood is used in preference to any other owing to its being easy to work and takes lac colours better than any other wood." There is thus no doubt whatever that the *Khirni* of Udaipur is **Wrightia tomentosa.**—*Letter No. 326 E, dated 4th December 1896.* In Ulwar this wood is spoken of as *Khirna*, it is used for toys and scabbards.

Zizyphus Jujuba, *Lamk.* (Rhamnaceæ), the *Bar* of Hoshiarpur, Shahpur; *Bordi, Sirdhi* of W. Rajputana.

C. 1491-1511.

TIMBERS USED IN LAC-TURNERY.

Holarrhena antidysenterica, *Wall.* (Apocynaceæ), the *Kura* of Saharanpur; the *Veppalai* supposed to be used in Vellore, North Arcot, for lac turnery.

Jasminum grandiflorum, *Linn.* (Oleaceæ), the *Chameli*-wood of Jaipur is good for toys, but too soft for charpoy legs.

Lagerstrœmia Flos-reginæ, *Retz.* (Lythraceæ), the *Ajur* of Assam.

Mangifera indica, *Linn.* (Anacardiaceæ), the mango is largely used in Agra; occasionally in Hoshiarpur, is only rarely used in Jaipur.

Melia Azedarach, *Linn.* (Meliaceæ), the *Drek* of Hoshiarpur.

Mesua ferrea, *Linn.* (Guttiferæ), the *Nohar* of Assam.

Millingtonia hortensis, *Linn. F.* (Bignoniaceæ), the *Akas nim* of Saharanpur.

Mimusops indica, *Kurz* (Sapotaceæ), the *Khirini* of Indergarh in Kohat State, Rajputana.

M. Kauki, *Linn.*, is said to be the *Khirni* of Shahpura in Rajputana, where it is said to be imported from Jaipur and Gwalior.

Morus indica, *Linn.* (Urticaceæ), the *Shahtut* is in Jaipur used for making *Dunkas* and snuff boxes.

Olea cuspidata, *Wall* (Oleaceæ), the *Kau* of Shahpur.

Pinus longifolia, *Roxb.* (Coniferæ), the *Chil* of Hoshiarpur.

Populus euphratica, *Oliv.* (Salicaceæ), the *Bhan* of Shahpur; this is the *Bahan* of Haidrabad, Sind, where it is extensively used and much appreciated for turnery owing to its taking colour easily; it is a common tree in Sind especially on river banks.

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All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place, according to the letter and number shown at the bottom of each page.

(Foods and Fodders.)

N 2/396

THE

AGRICULTURAL LEDGER.

1901—No. 10.

FOOD GRAINS AND FODDERS.

(INDIA.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. III., F. 669-74.*]

INDIAN FOOD GRAINS AND FODDERS: THEIR CHEMICAL COMPOSITION.

By DR. J. WALTER LEATHER, F.I.C., F.C.S., *Assistant Agricultural Chemist to the Government of India.*

Other PAPERS that may be consulted:

The Agricultural Ledger, 1892, No. 1; 1893, No. 15; 1894, No. 2; 1896, No. 40; 1898, No. 19, 1899, Nos. 1, 4; 1900, No. 1.



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1901.

The objects of THE AGRICULTURAL LEDGER are:—

(1) To provide information connected with agriculture or with economic product in a form which will admit of its ready transfer to ledgers;

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary in all offices concerned in agricultural subjects throughout India, so tha references to ledger entries made in any report or publication may be readil utilised in all offices where ledgers are kept,

(3) To admit of the circulation, in convenient form, of information on any subje connected with agriculture or economic products to officials or other persor interested therein,

(4) To secure a connection between all papers of interest publi[illegible] relating to economic products and the official Dicti ducts. With this object the information publis uniformly be given under the name and number which they more especially amplify. When the su been taken up in the Dictionary, the position it w in future issues of that work will be assigned to it.

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At the end of the year a printed index and title page w annual volume and after a period of, say, five years a will be issued for each series. It has been found tha scribe for a certain series only, and do not care to rec ive [illegible] new arrangement, while permitting of the formation f an annual volur will at the same time retain the serial classification.

[*DICTIONARY* (

INDIAN FOOD (

By DR. J. WALTER LEA

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CULTURAL LEDGER.

1901—No. 10.

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FOOD GRAINS AND FODDERS.

(INDIA.)

[*Dictionary of Economic Products, Vol. VIII*, F. 669-74.]

Other PAPERS that may be consulted:

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IDIAN FOOD GRAINS AND FODDERS: THEIR CHEMICAL COMPOSITION

By Dr. J. WALTER LEATHER F.I.C., F.C.S., *Asst. Agricultural Chemist to the Government of India.*

PLAN OF THIS PAPER.

In the following pages will be found information regarding the ᵕnposition of some of the Indian food grains and fodders. It ıcipated that a second edition of this work can be issued in . twelve months, when much will be added to it. It will, how- prove of assistance to the author, if those interested in the ct will in the meantime kindly communicate to him any sugges- which occur to them as being useful. With regard to the ıgement, among other things, it may prove more convenient for some readers if the following were adopted in future:—Part I, Grains, (*a*) cereals and millets, (*b*) pulses, (*c*) oil-seeds. Part II, Fodders, (*a*) cereals, millets and grasses, (*b*) pulse crops, (*c*) oil-seed crops. Part III, Oil-cakes. Part IV, Roots and tubers; the individual groups being arranged alphabetically according to their botanical names.

In this edition the food grains and fodders are arranged under their botanical names, in simple alphabetical order, and the chief local names are added.

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PLAN OF THIS PAPER.

An accurate knowledge of the chemical composition of the Food crops of any country is of importance. In the case of India, the information of this nature, which has been available in the past, is very limited. On the other hand the number of crops of different natural orders is larger than in most countries, and that of varieties of the same crop is correspondingly greater. Consequently, the chemical analysis of only a few specimens of each of these varieties would entail a work of very considerable magnitude. Such, for the present, is not being attempted. If, however, the chief characteristics of the composition of the principal crops is determined, a want which is experienced by those who are studying Indian agriculture will be in part supplied.

The source from which the samples have been obtained is stated for each sample. Some few of the analyses were made during the time Mr. S. H. Collins held charge of the laboratory and their authorship is hereby acknowledged. These analyses are marked with a † .

METHOD OF ANALYSIS.

Regarding the methods of analysis a few words may be usefully added. These are not quite uniformly the same in all countries, and consequently the published analyses of food stuffs are not always comparable in details. The following notes are therefore made.

Moisture.—This has been determined in all cases by drying in an air-oven at about 100° c.

The *oil* has been extracted from the *air-dry* sample with rectified, but not desiccated, ether.

The ether extract has usually only been determined in the grain, in which case it may be assumed to be almost entirely oil.

In the green fodders and straw or *bhusa* of crops, the matter soluble in ether includes largely other substances than oil, such as wax, chlorophyl or even Alkaloids in some cases. It has, therefore, been generally omitted from the analysis of these materials.

Albuminoids.—In some of the older samples, the proportion of Albuminoid nitrogen was not separately determined, and for these the amount of total nitrogen has been multiplied by the usual factor 6·25 and the product entered as Albuminoids. All such have been marked with an * . In all the samples marked 99 or co, the Albuminoid Nitrogen was separated by Retthousen's method (precipitation with Capric hydrate). In a few other cases Church's

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method was employed. As will be seen, nearly the whole of the nitrogen in grain exists as Albuminoids; it is only in fodders that any very marked divergence exists between the amounts of total and Albuminoid Nitrogen.

Soluble Carbohydrates.—This term is applied to the [illegible] those component parts of food stuffs which are not separately determined.

In cereals and pulses it includes principally starch, but in other cases, such as some of the oil seeds, there is but little starch, its place being taken by such substances as pectin or mucilage.

Woody Fibre.—This includes principally cellulose, but any lignin which is present in the grain or fodder is included.

Soluble Mineral Matter.—Most of the samples were very clean and free from earthy admixture. But since when collecting earth was usually present and difficult to remove thoroughly, the soluble part of the "ash" or mineral matter has been stated separately, and the other insoluble portion, which consists principally of the silica natural to the grain or fodder has been entered in the last column. Usually grain contains very little silica, and if any earthy matter was adhering to the sample, its presence is at once indicated. But the straws and grasses contain high proportions of silica as an integral part of their normal composition. Earth or dust also usually adheres to these fodders, which is only partially removed on the threshing floor. Information regarding the composition of the ash will be supplied later.

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Botanical Name—Andropogon halepensis—(*Sorghum saccharatum.*)
English Name—American Sorghum.
Vernacular Name—*Shalu.*

GREEN FODDER.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
18—96	Reaped green . . .	Nagpore . .	70·96	...	·81	12·14	12·57	1·23	2·29	·18	·13
20—96	" ripe . . .	" . .	57·15	..	1·22	19·17	18·13	1·29	3·04	·26	·19

Botanical Name—Andropogon Sorghum—(*Sorghum vulgare.*)
English Name—The Indian or Great Millet.
Vernacular Names—*Juar, Cholum.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
63—98	White fine . . .	Surat . . .	12·04	3·06	7·10	74·45	1·39	1·64	·32	1·21	1·13
64—98	" 2nd class . .	... . . .	11·55	3·50	6·00	76·70	·96	1·24	·05	1·05	·96
65—98	Red cheap-grain . .	... . . .	12·08	3·22	9·92	71·47	1·17	1·37	·27	1·67	1·58
273—99	"Khena" . . .	Poona . . .	9·98	3·61	11·87	71·54	1·12	1·31	·05	1·96	1·81
278—99	"Nilwa" . . .	" . . .	10·43	4·45	11·19	70·99	1·18	1·73	·05	1·91	1·79
279—99	"Dudh Mogra" . .	" . . .	10·21	4·13	10·19	71·90	1·22	2·11	·24	1·74	1·63
280—99	"Mal dandi" . .	" . . .	8·76	3·47	9·57	74·20	1·75	1·02	·38	1·65	1·53
281—99	"Sundia" . . .	" . . .	9·90	4·59	12·44	70·05	·79	1·83	·40	2·11	1·99
23—96	... . . .	Nagpore . .	9·96	7·66	7·69	70·15	2·24	1·67	·63	1·26	1·23

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Botanical Name—Sorghum Andropogon—(*Sorghum vulgare.*)

English Name—The Indian or Great Millet.

Vernacular Names—*Juar, Cholum.*

FODDER.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
			Sun-dried Samples.								
356—95	......	Aligarh	8·35	...	4·19	47·85	33·59	3·28	2·74	·70	67
24—96	Dead ripe	Nagpore	10·79	...	2·24	51·57	25·42	3·04	6·94	49	·36
174—98†	Sundia not quite ripe	Poona	8·04	2·19	3·83	47·98	27·90	2·91	7·15	·64	·61
175—98†	Kawbi not quite ripe	"	7·35	2·11	2·29	46·27	31·38	3·45	7·15	·41	·37
			Fresh-cut Samples.								
19—96	Cut green	Nagpore	69·76	...	·55	14·74	11·90	1·17	1·88	·113	·088
21—96	Cut ripe	"	67·02	...	·64	16·42	12·78	1·52	1·62	·173	·103
317—96	Cut in October	Cawnpore	56·10	...	3·10	20·65	15·32	2·29	2·54	·56	·50
318—96	2nd cutting in March	"	63·77	...	1·54	18·50	10·35	1·77	4·07	·42	·25
319—96	Cut in March	"	48·78	...	2·01	25·31	15·92	2·10	5·88	·43	·32

Botanical Name—Arachis hypogæa.
English Names—Ground Nut, Earth Nut, Pea Nut.
Vernacular Names—*Múngphali, vilydell-mung.*

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
58—93	(Kernels only) . .	......	4·70	49·25	29·09*	13·21	1·65	2·15	·05	4·65	...

Botanical Name—Arachis hypogæa.
English Names—Ground Nut, Earth Nut, Pea Nut.
Vernacular Names—*Múngphali, vildyell-múng.*

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
57—93	(Shells only) . . .	......	7·35	2·80	7·57*	13·73	55·35	9·45	3·75	1·21	...

Botanical Name—Avena sativa.
English Name—Oats.
Vernacular Name—*Jai.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
†6—93	......	Dehra Dun . .	10·17	5·27	6·39	61·57	11·29	1·89	3·42	1·18	1·02
173—93	Cape Oats . . .	......	10·80	5·93	8·77*	57·95	12·50	1·25	2·80	1·40	..

Botanical Name—Avena sativa.
English Name—Oats.
Vernacular Name—*Jai.*

STRAW.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
203—94	......	Cawnpore . .	9·53	—	1·37	43·48	36·03	3·72	5·81	...	·22

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FOOD GRAINS, ETC. Indian Food Grains and Fodders :

Botanical Name—Brassica campestris.
English Name—
Vernacular Name—
GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	eral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
186—93	"Yellow Sarson" . .	Cawnpore . .	6·15	41·37	23·61*	22·25	2·97	3·40	·25	3·76	...
187—93	"Black Sarson" . .	" . .	7·15	33·87	25·89*	22·04	6·40	4·30	·35	4·14	...
193—93	"Rai"	" . .	7·50	28·90	16·29*	31·87	5·43	6·16	3·85	2·61	...

Botanical Name—Cajanus indicus.
English Names—Pigeon Pea, Congo Pea.
Vernacular Names—*Arhar, Tor, Tur.*
GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
79—99	Red	Poona . . .	8·03	1·32	19·38	61·39	5·94	3·80	·09	3·35	3·10
90—99	White	" . . .	7·92	1·23	18·69	62·64	5·99	3·44	·09	3·44	2·99
271—99	"	" . . .	8·64	1·91	19·19	60·38	5·24	3·66	·58	3·41	3·07

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Botanical Name—**Cajanus indicus.**

English Names—Pigeon Pea, Congo Pea.

Vernacular Names—*Arhar, Tor, Tur.*

STRAW OR "BHUSA" (PRINCIPALLY LEAVES AND PODS).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
54—99	"White" . . .	Poona . . .	6·77	6·93	13·25	51·38	18·10	6·44	3·13	2·45	2·12
55—99	"Red"	" . . .	6·22	7·94	14·94	46·51	14·35	6·12	3·92	2·60	2·39
266—99	...	" . . .	8·89	2·97	7·38	49·94	21·74	6·46	2·62	1·42	1·18
205—94	. ...	Cawnpore . .	5·58	...	7·39	45·74	25·69	6·23	8·37	..	1·18

Botanical Name—**Carthamus tinctorius.**

English Names—Safflower, American Saffron.

Vernacular Names—*Kusumba, Kusum, Kurdi, Kar.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
93—93	......	Poona . . .	7·49	31·84	13·31*	18·66	26·31	2·39	...	2·13	...
15—98†	......	" . . .	5·11	27·08	8·41	22·58	32·69	1·83	·30	2·17	1·34
92—99	......	" . . .	6·04	18·28	20·44	27·51	23·60	3·78	·35	3·77	3·27

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Botanical Name—Carthamus tinctorius.

English Names—Safflower, American Saffron.

Vernacular Names—*Kusum, Kusumba, Kurdi, Kar.*

OIL CAKE.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
16—98†	......	Poona . . .	12·00	3·78	16·91	41·48	19·40	4·36	2·07	4·92	2·70

Botanical Name—Cicer Arietinum.

English Names—Common Gram, Chick Pea.

Vernacular Name—*Chana.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
24—98†	......	Dehra Dun . .	9·88	3·95	17·05	60·03	6·51	2·40	·18	2·72	2·98
82—99	......	Poona . . .	7·99	3·89	21·37	54·97	8·32	3·16	·30	3·73	3·42
212—99	......	" . . .	8·60	5·31	15·50	60·13	7·21	3·06	·19	2·71	2·48
182—93	......	Cawnpore . .	11·35	4·83	18·57*	56·33	6·17	2·75	...	2·96	...

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Botanical Name—Cicer Arietinum.

English Names—Common gram, Chick Pea.

Vernacular Name—*Chana.*

STRAW OR "BHUSA" (STEMS, LEAVES AND PODS.)

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
57—99	......	Poona . . .	6·56	2·69	3·06	44·55	28·93	9·29	4·92	·68	·49
264—99	......	" . . .	8·21	2·64	2·94	49·70	21·87	11·81	2·83	·67	·47
204—94	......	Cawnpore . .	10·11	...	4·46	38·84	27·63	9·66	9·30	...	·71

Botanical Name—Cocos Nucifera.

English Name—Cocoa Nut.

Vernacular Names—*Nárel, dab.*

THE CAKE.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
23—98	......	Poona . . .	7·72	16·53	13·62	44·57	12·45	4·65	·45	3·31	2·17

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Botanical Name—Cyamopsis psoralioides.

English Name—

Vernacular Names—*Guar, Khurti, Khulti, Guwar.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen	Albuminoid Nitrogen.
108—99	...	Poona . . .	8·99	2·99	28·31	48·42	7·68	3·32	·29	4·93	4·53

Botanical Name—Dalichos biflorus. D. uniflorus.

English Name—Horse gram.

Vernacular Name—*Kulthi, kalathi.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
101—99	......	Poona . . .	7·45	·89	20·06	60·62	4·57	4·34	2·07	3·74	3·21

Botanical Name—**Dolichos Lablab.**

English Name—

Vernacular Names—*Sem, Lobia, Val, Wal.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
266—99	......	Poona . . .	7·11	·93	23·31	56·98	6·94	3·99	·74	4·06	3·73
267—99	"Mettia" . . .	" . . .	9·55	2·03	23·44	53·26	7·42	4·20	·10	4·07	3·75
268—99	"Kadawa" . . .	" . . .	9·08	1·11	20·75	58·38	6·78	3·85	·05	3·46	3·32
269—99	"Damania" . . .	" . . .	9·70	1·74	19·56	61·94	4·69	2·02	·35	3·24	3·13
270—99	"Watania" . . .	" . . .	9·19	1·17	23·31	55·35	6·12	3·69	1·17	3·98	3·73

Botanical Name—**Dolichos Lablab.**

English Name—

Vernacular Names—*Sem, Lobia, Val, Wal.*

"BHUSA" (STEM, LEAVES AND PODS).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
263—99	......	Poona . . .	9·92	3·72	13·27	45·04	16·17	11·27	2·51	2·56	2·14

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FOOD GRAINS, ETC. Indian Food Grains and Fodders:

Botanical Name—Guizotia abyssynica.

English Name—Niger seed.

Veranсular Names—*Kala til, Ramatila.*

No	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
03—90	...	Poona . . .	4·88	38·03	19·31	17·47	9·20	6·69	4·42	3·19	3·09
173—95	..	Lucknow . .	8·43	38·20	19·25*	11·49	15·19	4·36	3·08	3·08	...
272—91	...	Poona . . .	6·15	41·14	20·09*	15·08	12·10	4·37	1·09	3·24	...

Botanical Name—Hordeum Vulgare.

English Name—Barley.

Vernacular Names—*Jao, Jaw, Jav, Satu.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
4—95†	......	Cawnpore . .	11·85	1·84	8·04*	72·65	3·24	1·09	·39	1·29	...
168—93	"White huskless" . .	Poona . . .	12·18	1·83	7·92*	74·12	2·10	1·00	·85	1·26	...
164—93	"Country white" . .	" . . .	13·74	1·80	8·29*	70·32	3·49	1·76	·60	1·33	...
165—93	" " black" . .	" . . .	12·55	1·91	7·73*	69·71	5·63	·85	1·60	1·24	...
166—93	"Chocolate" . . .	" . . .	12·79	1·97	8·24*	73·23	1·73	1·89	·15	1·32	...

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Botanical Name—**Hordeum Vulgare.**
English Name—Barley.
Vernacular Names—*Jao, Jaw, Jav, Satu.*

"BHUSA" (STRAW AND CHAFF).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
202—93	......	Cawnpore . .	7·93	...	4·00	41·45	34·82	5·55	6·25	...	·64

Botanical Name—**Lathyrus sativus.**
English Name—Wood Pea.
Vernacular Names—*Khesari, Karas, Lakh, Lang.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
107—99	......	Poona . . .	7·39	·79	24·69	57·98	4·83	3·18	1·10	4·21	3·05

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Botanical Name—**Lathyrus sativus.**

English Name—Wood Pea.

Vernacular Names—*Khesari, Karat, Lakh, Lang.*

BHUSA (STEMS, LEAVES AND PODS).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
56—99	... ..	Poona . . .	6·10	5·00	9·75	45·39	19·36	9·49	4·91	1·96	1·56
255—99	. . .	" . . .	11·08	2·93	9·23	43·03	20·57	10·46	2·68	1·66	1·32

Botanical Name—**Lens esculenta.**

English Name—Lentil.

Vernacular Name—*Masur.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
103—99	......	Poona . . .	8·03	1·06	23·00	61·14	2·42	3·54	·81	3·94	3·68

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Botanical Name—Linum usitatassimum.

English Name—Linseed.

Vernacular Names—*Alsi, Alshi, Javas.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
94—99	Brown . .	Poona . . .	4·97	37·47	20·92	26·24	5·60	3·96	·84	3·71	3·35

Botanical Name—Medicago sativa.

English Name—Lucerne.

Vernacular Names—Wilayti-gawuth, alfalfa.

GREEN FODDER.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
51—99	..	Poona . . .	77·75	·76	3·00	11·89	3·74	2·75	·11	·71	·48
53—99	...	" . . .	78·32	·75	3·81	11·21	3·35	2·44	·12	·81	·61

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Botanical Name—Panicum Frumentaceum.

English Name—Millet.

Vernacular Names—*Sawan, Sawank, Sawa, Bavio, Bunti.*

GRAIN.

No.	Local description	Source.	Moisture	Oil	Albuminoids	Soluble Carbohydrates	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen	Albuminoid Nitrogen.
50—99	. ..	Poona . . .	7·72	4·39	7·06	67·56	7·44	1·70	4·13	1·18	1·13

Botanical Name—Panicum jumentorum.

English Name—Guinea grass.

Vernacular Name—*Gini Ghas.*

GREEN FODDER.

No	Local description.	Source.	Moisture.	Oil.	Albuminoids	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen	Albuminoid Nitrogen.
50—99	......	Poona . . .	63·38	·84	1·88	19·36	8·79	2·60	3·15	·41	·30
52—99	.. ...	" . . .	71·35	1·05	2·62	13·71	5·73	1·87	3·47	·53	·42

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Botanical Name—**Panicum miliaceum.**

English Name—Common Millet.

Vernacular Names—China, Salar, Sava, Vari, Varagu.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
97—99	....	Poona . . .	8·57	·09	9·38	64·21	6·30	2·50	3·95	1·52	1·50

Botanical Name—**Panicum miliare.**

English Name—Little Millet.

Vernacular Names—Kutki, Avarai.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
—99		Poona . . .	7·95	4·11	6·81	67·26	7·63	2·16	4·08	1·18	1·09

Botanical Name—Paspalum scrobiculatum.

English Name—

Vernacular Names—*Kodo, Kodon, Kodra.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
85—99	......	Poona . . .	8·01	3·36	5·81	70·06	8·47	1·34	2·95	1·00	·93

Botanical Name—Pennisetum typhoideum.

English Names—Bulrush Millet, Spiked Millet.

Vernacular Names—*Bajra, Kumbu.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
81—99	......	Poona . . .	8·05	5·36	9·88	74·26	·60	1·60	·25	1·72	1·58
84—99	"Bhownaggari" . .	" . . .	8·60	5·37	9·37	73·94	·86	1·68	·18	1·58	1·41
91—99	"Awned" . . .	" . . .	8·09	5·50	10·00	72·99	·60	2·12	·68	1·70	1·60
95—99	"Nadiad" . . .	" . . .	8·87	5·08	8·62	74·75	·90	1·59	·19	1·47	1·38
96—99	"Poona" . . .	" . . .	8·96	5·75	8·12	74·11	·93	1·74	·39	1·34	1·30

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Botanical Name—Phaseolus aconitifolius.

English Name—

Vernacular Names—*Moth, Mut.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
105—99	......	Poona . . .	8·59	1·07	22·50	58·85	4·24	3·99	·76	4·01	3·60

Botanical Name—Phaseolus Mungo.

English Name—Green gram.

Vernacular Names—*Mung, Mug.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
104—99	......	Poona . . .	9·48	1·83	23·56	56·39	4·42	4·02	·30	4·03	3·77

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FOOD GRAINS, ETC. Indian Food Grains and Fodders:

Botanical Name—Phaseolus radiatus.
English Name—
Vernacular Names—*Urd, Urad, Mash.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
136—98†	......	Poona . . .	11·87	·70	16·08	54·35	3·39	2·45	1·16	2·90	2·57
100—99	......	" . . .	8·14	·99	18·50	59·11	4·33	4·51	4·42	3·24	2·96

Botanical Name—Pisum sativum.
English Name—Garden pea.
Vernacular Names—*Bara-Mattar, Sen, Vatane, Watana.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
180—93	White	Cawnpore . .	12·05	1·27	24·12*	54·44	5·41	2·65	...	3·84	...
181—93	Black	" . .	11·25	1·47	24·67*	52·47	6·67	3·30	·15	3·95	...
99—99	Vatane	Poona . .	7·89	1·40	20·06	62·12	5·69	2·79	·05	3·38	3·21

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Botanical Name—Pisum sativum.
English Name—Garden pea.
Vernacular Names—*Bara-Mattar, Sen, Vatane, Watana.*
"Dhusa" (Stems, leaves and pods).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
[illegible]	"Pea Straw"	Poona	7·27	3·02	11·75	42·43	19·36	9·65	6·52	2·49	1·83
[illegible]		Cawnpore	9·88	...	9·94	42·83	22·27	9·35	5·73	...	1·59

Botanical Name—Sesamum indicum.
English Names—Gingelly, Sesame.
Vernacular Names—*Til, Gingili.*
Grain.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
[illegible]	"Red"	Poona	4·18	49·72	[illegible]	14·15	[illegible]	6·45	[illegible]	[illegible]	[illegible]
[illegible]	"Black"	"	4·23	[illegible]	[illegible]	[illegible]	4·14	6·55	[illegible]	3·11	[illegible]
[illegible]	"White"	"	4·21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Nagar	[illegible]	45·15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	...
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4·13	...
[illegible]	[illegible]	Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1·35	[illegible]	...

F. 0074.

Botanical Name—Phaseolus radiatus.

English Name—

Vernacular Names—*Urd, Urad, Mash.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
136—98†	......	Poona . . .	11'87	'70	16'08	54'35	3'39	2'45	1'16	2'90	2'57
100—99	......	" . . .	8'14	'99	18'50	59'11	4'33	4'51	4'42	3'24	2'96

Botanical Name—Pisum sativum.

English Name—Garden pea.

Vernacular Names—*Bara-Mattar, Sen, Valane, Watana.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
180—93	White	Cawnpore . .	12'05	1'27	24'12*	54'44	5'41	2'65	...	3'84	...
181—93	Black	" . .	11'25	1'47	24'67*	52'47	6'67	3'30	'15	3'95	...
99—99	Vatane	Poona . .	7'89	1'40	20'06	62'12	5'69	2'79	'05	3'38	3'21

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Botanical Name—Triticum vulgare (*T. sativum*).
English Name—Wheat.
Vernacular Name—*Gehun*.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
1—98	......	Cawnpore	12'72	1'84	9'10	72'88	1'68	1'72	'12	1'46	
151—93	Country bearded	,,	13'35	1'73	8'47	73'08	1'57	1'75	'05	1'36	...
152—93	Country beardless	,,	13'19	1'60	9'75	72'03	1'93	1'40	'10	1'56	...
153—93	Buxa	,,	12'95	2'13	8'91	72'70	1'56	1'70	'05	1'43	...
154—93	Sindhi	,,	12'21	1'66	9'92	72'68	1'73	1'80	..	1'59	...

Botanical Name—Triticum vulgare. (*T. sativum*).
English Name—Wheat.
Vernacular Name—*Gehun* (*Choker*).

BRANS.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
[illegible]	......	Dehra Dun	[illegible]	4'94	7'55	65'78	5'47	3'14	'18	1'45	1'21
[illegible]	......	Poona	[illegible]	4'19	[illegible]*	[illegible]	9'27	[illegible]	'44	1'74	...
1899	......	,,	[illegible]	[illegible]	[illegible]*	[illegible]	6'29	[illegible]	'27	[illegible]	...

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FOOD GRAINS, ETC. Indian Food Grains and Fodders; their Chemical Composition.

Name of product examined.	No	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates	Woody Fibre.	Soluble mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
Andropogon halepensis.												
Syn. Sorghum saccharatum.												
American sorghum.												
Vern.—*Shalu.*												
Green fodder . .	18—96	Reaped green .	Nagpur .	70·96	...	0·81	12·14	12·57	1·23	2·29	0·18	0·13
	20—96	„ ripe .	„ .	57·15	..	1·22	19·17	18·13	1·29	3·04	0·26	0·19
Andropogon Sorghum.												
Syn. Sorghum vulgare.												
Indian or Great Millet.												
Vern.—*Juar, cholum.*												
Grain . . .	63—98	White fine .	Surat .	12·04	3·06	7·10	74·45	1·39	1·64	0·32	1·21	1·13
	64—98	„ 2nd class	...	11·55	3·50	6·00	76·70	0·96	1·24	0·05	1·05	0·96
etc., etc.												

G. I. C. P. O.—No. 1193 R. & A.—5-8-1901.—2,230.—Jos. C.

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All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject matter is filed in its proper place, according to the letter and number shown at the bottom of each page

THE

AGRICULTURAL LEDGER.

1901—No. 11.

PTEROCARPUS MARSUPIUM.

KINO (TREE.)

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. I., P. 1370-80.*]

MALABAR KINO:

ITS COLLECTION COMPOSITION AND TRADE;

With a revision of the Dictionary article, by MR. D. HOOPER, F.C.S., F.L.S.

Other DICTIONARY articles that may be consulted:

Butea frondosa, Vol. I., B. 944-77.



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R Friedländer & Sohn, Carlstrasse, 11, Berlin, N.W.

Otto Harrassowitz, Leipzig.

Karl W. Hiersemann, Esq, Leipzig.

Ernest Leroux, Esq., 28, Rue Bonaparte, Paris.

Martinus Nijhoff, Esq., The Hague.

In India.

Messrs.

Thacker, Spink & *Co.*, Calcutta *and* Simla

Newman & Co, Calcutta.

Thacker & Co., Ld., Bombay.

Higginbotham & Co., Madras.

Superintendent, American Baptist Mission Press, Rangoon.

E Seymour Hale, Esq., Fort, Bombay.

Rai Sahib M. Golab Singh & Sons, Mufid-I-Am Press, Lahore.

A. J. Combridge & Co, Bombay.

THE
AGRICULTURAL LEDGER.

1901—No. 11.

PTEROCARPUS MARSUPIUM.

(KINO TREE.)

[*Dictionary of Economic Products, Vol. I., Pt. I.,* P. 1370-80.]

MALABAR KINO:

ITS COLLECTION, COMPOSITION AND TRADE;

With a revision of the Dictionary Article, by MR. D. HOOPER, F.C.S., F.L.S.

The revision of the article on Pterocarpus Marsupium in *The Dictionary of Economic Products* has been rendered necessary on account of the great interest attached to the recent fluctuation in the price of medicinal kino and its causes. During the course of an extensive correspondence between the Reporter on Economic Products and members of the Forest service, important additional information has been obtained with regard to the distribution of the tree and the collection and preparation of its juice for the European market. Authentic specimens of the kino from the different localities have been forwarded to the Reporter and deposited in the Economic Court of the Indian Museum, and an opportunity has been taken to subject the samples to comparative tests in the chemical laboratory, especially in respect to their tannin value. INTRODUCTORY.

The genuine Malabar kino is an important indigenous drug in India which has been recognised many years in the the British and other Pharmacopœias. An unlimited supply is now obtainable through the Forest Department and at a price that will preclude all competition of other articles of a similar nature.

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INTRODUCTORY.

Pterocarpus Marsupium, *Roxb., Fl. Br. Ind., II., 239; Ind. Kew., IV., 652.*

THE INDIAN KINO TREE.

Syn.—P. BILOBUS, *Roxb.*

Vern.—*Bija, bijasar, bijasal, piasal, pit-shola, banda,* HIND.; *Pit-shal, pit-sal,* BENG.; *Byasa, piasal, bijasa,* URIYA; *Hitun, hid, hed, hilum, paisar,* KOL.; *Murga, banda,* SANTAL; *Peddei, bijo,* GOND; *Radatbera,* BHIL; *Bija-sal, biah, bija-sah, bijaira, dhorbenla,* C.P.; *Bibla, bibla, huni, asana,* MAR; *Bibla, bia,* GUZ.; *Bibla, bewba, bia,* DEC.; *Vengai, yeanga, vengai-maram,* TAM.; *Peddagi yeanga, yeggi, yegisa, pedega, pedes, vegisa, egisa, vegi, pedyegi,* TEL; *Benga, honne, bibla, honnemaradabanke,* KAN.; *Hunne, karinthagara, venna, venna-maram,* MALAY; *Gummalu, ganmalu,* SING; *Katimukki,* ARAB.; THE GUM-*Hira-dokhi, kholar-manda, rang-barat,* HIND.; *Nat-ka-dam-mul-akhvain,* DEC.; *Kandamiruga-mirattam,* TAM.; *Gandam-rugam-netturu,* TEL.; *Vennopasha,* MALAY.; *Dam-mul-akhvaine-hindi,* ARAB.; *Khune-siyavushane-hindi,* PERS.

References.—*Roxb, Fl, Ind., Ed., C. B. C., 536; Voigt, Hort. Sub. Cal., 242, Brandis, Fl, 152; Beddome, Fl. Sylv, t. 21; Gamble, Man. Timb, 132; Dals. and Gibs, Bomb Fl., 76; Rev. A. Campbell, Rept. Econ. Pl. Chutia Nagpur, Nos. 9465, 9466; Sir W. Elliot, Fl. Andhr., 49, 190; Pharm. Ind., 70; Flück. and Hanb, Pharmacog, 194; Ainslie, Mat. Ind, II, 264; O'Shaughnessy, Beng. Dispens, 299; Medical Topog. Ajm., 131; Moodeen Sheriff, Supp. Pharm. Ind., 208; Murray, Pl. and Drugs, Sind, 128; Dymock, Mat. Med., W. Ind., 2nd Ed, 239, 888; Dymock, Warden and Hooper, Pharmacog. Ind. I., 464; Trans, Med. and Phys. Soc. Bomb. (New Series), No. 12,173; Birdwood, Bomb. Prod., 30, 266, 311, 329; Drury, U. Pl. Ind., 351; Useful Pl. Bomb. (XXV., Bomb. Gaz.), 62, 251, 394; Econ. Prod., N.-W. Prov., Pt. I. (Gums and Resins), 3; Gums and Resinous Prod. (P. W. Dept Rept.), 2, 3, 5, 7, 9, 25, 32, 65, 67; Cooke, Gums and Resins, 35; Wardle, Dye Rep., 26, Christy, New Com Pl, V., 39, 46, 44; Man. Madras, Adm, I., 313; II., 64; Nicholson, Man. Coimbatore, 401; Boswell, Man. Nellore, 101; Moore, Man. Trichino-poly, 79; Gribble, Man. Cuddapah, 199, 262; Settlement Reports.—Central Provinces, Nemar, 305; Raipur, 75; Chanda, App. VI.; Godavery, 37; Seonee, 10; Chindwara, 110, 111; Bhandara, 18; Gazetteers —Bombay, III., 199; VII., 37, 35, 39; XIII, 23; XV., 33; XVI., 19; XVII., 24; Central Provinces, 58, 503; Mysore and Coorg, I., 48, 71;*

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III., 21; Journals;—Agri-Horti. Soc, Ind. (Old Series) IV., Pro., 21; V., 110, 113; VIII., Sel., 140; IX., 294, Sel. 51, Pro., 149; XIV., Sel., 166; (New Series), IV., Pro., (1873), 38; VII., 136; Ind. Forester, I., 274; II., 18, 19; III., 23, 189, 201; IV, 292, 322, 366, 411; VI, 104, 304; VIII., 105, 118, 125, 126, 378, 411, 414, 415, 416, 417, 438, 439, 440; IX, 294, 356, 427; X., 33, 222, 325, 326, 547, 550, 552; XI., 230; XII., 85, 188, 313; XIII., 120; XIV., 151. Pharm. Journal, Vol. 64, 1549, p. 226. Chemist and Druggist, 1898; Feb. 26, p. 355; July 9, p. 57; July 30, p. 207. Indian Forester, October 1900 (Appendix). INTRODUCTORY.

Habitat.—A large deciduous tree of Southern and Central India and Ceylon, extending northwards as far as the Banda District of the North-Western Provinces. Most abundant in the North Malabar district of the Madras Presidency, where the juice is manufactured into the drug. The tree occurs in fair abundance in the Coimbatore, Nilgiri and Tinnevelly districts of the Madras Presidency, also in Berar and the Central Provinces. In all these localities kino might be obtained if a necessary demand arose. In the Northern and Southern Forest Circles of Bombay no kino industry exists, but the *Bibla* or *Bia* is a valuable timber tree especially in the Thana Division, and it would not pay Government to sacrifice a fixed revenue from timber for a product of much less value as the gum from the tree. In Hyderabad (Nizam's Dominions) **Pterocarpus Marsupium** is at present one of the most valuable reserved trees under the Forest Department.

Habitat.

Abundant in Madras.

Major D. Prain, I.M.S, in an appendix to the "Indian Forester," October, 1900, has arranged this species under two varieties, each of which shows two distinct geographical forms.

Var. *a.*—Form 1, *biloba;* occurs in Ceylon, and in Coimbatore, South India.

Form 2, *vera;* occurs in the Nilgiris, North Arcot, Nellore, Carnatic, Cuddapah, Bellary, Kurnool, Kistna, Mysore, Vizagapatam, Godaveri, Ganjam, Orissa, Sonthal Pergunnahs, Chota Nagpur, and Central Provinces.

Var. *β.*—Form 3, *acuta;* occurs in Rajmahal Hills, North-Western Provinces and Oudh, Kumaon, North Malabar, and Coorg.

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INTRODUCTORY.

Form 4, *acuminata;* occurs in Behar, Central Provinces, Berar, Central India, Deccan, Rajputana, Concan and Kanara.

History.

History.—Dr. Pereira remarks on the history of gum kino that "in 1757 Dr Fothergill described an astringent gum which he supposed (though on very loose evidence) to have been brought from the river Gambier, and hence he termed it Gummi rubrum astringens gambiense." In 1774 it was introduced into the Edinburgh Pharmacopœia as Gummi Kino, and in 1787 into the London Pharmacopœia as Resina Kino. It was described under this designation in the third edition of Lewis's *Exp. Hist. of the Mat. Med.*, by Dr. Aikin in 1784. In 1794 Schenck published an inaugural dissertation on it (Pereira, *Mat. Med.*, ii., 325).

The origin of the word is probably derived from *kano* the Mandigo name for Pterocarpus erinaceus which yields a similar gum in Africa. The Persian name for the drug is *Khune*, while in the Central Provinces *Kinta* is one of the names for Butea kino. The word has by some been referred to *Carnis* in allusion to the "flesh"-coloured appearance of the juice.

Malabar kino does not appear to have been noticed by Hindu or Mohammadan medical writers, and Dr. Ainslie in "Materia Indica" (ed. 1826, p. 185) states that the drug is but slightly known in India.

The drug has often been subject to adulteration, and in 1841 Dr. Pereira detected many impurities in it. The gum of Butea frondosa has occasionally been substituted for the official kino, and this exudation, both in its natural state, and as met with in the bazars, is of very inferior quality.

Collection.

Collection.—The manufacture of kino from the juice of the *Vengai* (Pterocarpus Marsupium) is conducted in the district of North Malabar. Anjurakandy, a village at the foot of the ghats, is supposed to be the site of the factory where the first supply was prepared for the market early in the past century.

Season for collecting.

The best season for collecting kino is in the dry weather during February and March when the trees are in blossom. The gum is of inferior quality during the rains, and in the process of drying at this season the use of artificial heat would have to be resorted to. The tree "bleeds" pretty freely at all times of the year.

The Karambars or hill tribesmen of the district, whose chief

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COLLECTION OF KINO.

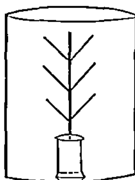
means of livelihood is the collection of minor forest produce, have hitherto employed very wasteful methods in extracting the juice.

The right to tap the trees is now put up to auction together with that of collecting other forest produce such as beeswax and honey. In other cases the tapping is conducted by rangers under the supervision of the district forest officers; the collection is undertaken subject to the condition of its being done properly and without causing undue damage to the trees.

A few years ago, Mr. J. G. F. Marshall, the District Forest Officer, adopted the following method of collecting it.

Method of preparatio

A longitudinal cut is made with an axe or with a knife called *macha katti* through the bark of the trees down to the cambium about $1\frac{1}{2}$ foot long, and side cuts are made to lead into this. A bamboo tube is then fixed at the bottom of the main incision in order to catch the juice thus—



In the course of about twenty-four hours the flow of the gum ceases, and the bamboo is taken down. When several of these bamboo cups are nearly full they are taken to head-quarters and emptied into a large cauldron, and the juice is boiled. During the boiling, the impurities, consisting of pieces of bark, wood and leaves, rise to the surface and are skimmed off. When sufficiently concentrated to the consistence of a thick extract, it is exposed to the sun in thin layers in shallow vessels until it is dry enough to crumble to pieces. The kino is then weighed and packed away in wooden boxes.

Present method of drying.

The present District Forest Officer, North Malabar, has adopted the plan of drying the juice in shallow trays in the shade. The trays

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In addition to Butea kino which is sometimes offered as a substitute for true kino, the astringent gum of Bombax known as *Mocha rus* is occasionally used. The kino obtained from Pterocarpus dalbergioides, the Padouk tree of the Andamans, is very similar in compositon to that of the *Vengai*. Very little is known about the exudations of Ougeinia dalbergioides and Sesbania grandiflora which are said to resemble the Malabar drug. The red juice of certain wild nutmeg trees (Myristica gibbosa and M. Kingii) has recently been studied and found to have a remarkable resemblance to the official kino. (See *Agricultural Ledger* No. 5 of 1900.) COLLECTION OF KINO. Kino substitutes.

Chemistry.—Kino consists chiefly of kino-tannic acid, a catechol tannin giving a green reaction with ferric salts. A. Bergholz in 1884 found it to yield carbon 59·65 and hydrogen 4·87 per cent. Boiled with dilute sulphuric acid it affords insoluble kino-red or phlobaphene, and fused with potash it yields, as in Gambier and Cutch, protocatechuic acid and phloroglucol. A solution of kino in water is of a reddish colour, which develops a violet hue when a trace of alkali or a fragment of alkaline acetate is added together with a little ferrous sulphate. CHEMISTRY OF KINO.

Kino yields to ether a minute percentage of crystalline pyrocatechin, which is soluble in water, and assumes a green colour in contact with ferric chloride, and turns red on the addition of an alkali. Pyrocatechin.

K. Etti in 1878 extracted kinoin in colourless crystals by boiling Malabar kino with twice its weight of hydrochloric acid of specific gravity 1·03°. A solution of kinoin reddens in contact with ferric salts. Kinoin

Notwithstanding the known astringency of the drug, the amount of tannic acid—the active principle—has rarely been estimated. The earliest analysis was made by "citoyen" Vauquelin in 1803, and recorded in a paper entitled "Experiences sur la gomme kino, ainsi vulgairement appellée." (*Ann. Chim*, 46, 321). East Indian kino was found by Vauquelin to consist of 75 per cent. of tannin and peculiar extractive, 24 per cent. of red gum, and 1 per cent. of insoluble matter. Although we are unable to learn much of the constituents of kino from these results, the small amount of insoluble matter indicates a degree of purity in the commercial article at the beginning of the century equal to that of the best kino now produced. Tannin. Vauquelin's analysis.

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CHEMISTRY OF KINO.

Analysis by Will and Branch.

Some recent experiments performed by Messrs. Will and Branch have tended to show that while Malabar kino is highly soluble and pure the amount of tannic acid only reaches to about half the weight of the drug.

This series of experiments was made with the object of determining any variation in the composition of kino according to the methods used in drying it. The six samples had been prepared in the following manner:—

No. 1. The juice after collection was boiled and the liquid allowed to dry; this process occupying several weeks.

No. 2. The juice was dried in vessels heated with steam, and only occupied four hours.

No. 3. The juice was spread in layers and exposed to the sun, and dried in twelve hours.

No. 4. The juice was spread in layers about ¼-inch thick and dried in the shade; time required, twenty-four hours.

No. 5. Kino made from unboiled juice.

No. 6. Kino made from boiled juice.

The results of the examination are here tabulated—

	1	2	3	4	5	6
Percentage Soluble in water . .	57	77·4	79·6	77·6	77	58
" " rectified spirit .	78	85·0	81·0	84·0	83	77
" " proof spirit .	78·5	84·0	86·5	83·5	85	79·5
Tannin	39·3	49·2	49·8	45·3	55·1	41·1
Ash	1·3	1·1	1·1	1·3	·8	·7

Here it is seen that the kino dried by artificial heat agrees with that dried by the heat of the sun, and that boiling the juice has a somewhat deleterious effect upon the product.

The figures for tannin are very low, probably on account of the employment of a process for its estimation which has now been superseded.

Examination of Indian Museum samples.

Samples of kino have been examined in the chemical laboratory in the Economic Section of the Indian Museum, with a view to determine more particularly the amount of tannin, moisture and ash.

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CHEMISTRY OF KINO.

Examination of Indian Museum samples.

The following ten samples of kino were received from Forest Officers, and, although not all from Malabar, they were obtained from the official botanical source :—

No. 1. From Mudumalai, Nilgiri-Wynaad; a clean sample prepared direct from the juice and sent by Mr. E. D. M. Hooper *in November, 1896 (Reg. No. 8403).*

No. 2. Specimen collected at Kollegal, North Coimbatore (Reg. *No. 10012).*

No. 3. *Specimen collected in the Papanassam Hills, Tinnevelly* District (Reg. No. 10012-1). The two samples were forwarded by Mr. Hooper in September, 1897.

No. 4. Specimen collected near Chokanhâlli in the Sigur range, on the northern slopes of the Nilgiri Hills. Owing to the dryness of the ground the trees here do not bleed freely, and the gum was extracted with some difficulty. *Sent by Mr. J. W. Cherry,* Conservator of Forests, Southern Circle, Madras, in January, 1898 (Reg. No. 10324).

No. 5. A sample of kino collected in Malabar and supplied to the Madras Medical Store Department (Reg. No. 10381).

No. 6. Sample of mixed shade and sun-dried gum prepared in North Malabar. Forwarded at the instance of the Inspector General of Forests in March, 1898 (Reg. No. 10455).

No. 7. Specimen from Mohenli block, Chanda District, Central Provinces, where the growth of the trees is most vigorous. Sent by Mr. Hooper in August, 1897 (Reg. No. 9901).

No. 8. Kino from Chanda District, Central Provinces. Sent by Mr. A. E. Lowrie, Divisional Forest Officer, August, 1898 (Reg. No. 11100).

No. 9. A sample specially prepared by the same officer and sent in September, 1898 (Reg. No. *11379).*

No. 10. A sample of kino as now prepared in the shade in North Malabar. Received from Mr. H. Tireman, District Forest Officer, in April 1899 (Reg. No. 11989).

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CHEMISTRY OF KINO.

Composition.

The following table exhibits the results of the analyses of the various specimens:—

	Water.	Tannin.	Non-tannins.	In-soluble.	Ash.	Tannin in dry sub-stance.
1. Wynaad	15·7	79·0	3·8	...	1·5	93·7
2. Coimbatore	14·6	82·4	1·6	0·4	1·0	96·5
3. Tinnevelly	15·7	79·6	1·1	1·3	2·3	94·4
4. Nilgiris	15·3	79·1	4·1	...	1·5	93·7
5. Malabar	14·7	79·5	4·2	...	1·6	93·2
6. "	14·9	78·4	4·6	1·0	1·1	92·1
7. Central Provinces	13·5	76·4	4·0	4·0	2·1	88·3
8. " "	12·2	70·4	10·6	5·1	1·7	80·2
9. " "	15·1	70·0	11·5	1·5	1·9	82·4
10. Malabar	14·7	82·8	1·6	...	0·9	97·0

The astringent character of Pterocarpus kino is very marked according to these results. Including the three samples from the Central Provinces which were collected as an experiment, and were inferior as regards appearence, the average yield of tannic acid in the dry substance is over 90 per cent.

Pharmacopœia tests

The tests for kino in the British Pharmacopœia for 1898 require that it should "be partially soluble in cold water: almost entirely soluble in alcohol (90 per cent.). Yields little or nothing to ether. Not less than 80 per cent. should be soluble in boiling water." These tests are quite consistent with the above results. The 80 per cent. of extractive matter, which could be equally well separated by means of cold instead of boiling water, together with 15 per cent. of moisture natural to the kino, would leave a margin of 5 per cent. for insoluble impurities.

Gelatinisation of tincture.

The above tests were made on fresh specimens of dried juice, and it is probable that this accounts for their superiority. It is a well known fact that tinctures of kino made with spirit become gelatinised on keeping, due to the formation of a modified form of tannic acid. It might be surmised therefore that the kino even in a dried state is liable to be rendered less soluble when kept for any length of time.

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COMMERCE.

Commerce.—In North Malabar alone about 2,000 pounds of kino can be produced annually, at the cost price of three to four annas a pound. Except for the requisition of the Medical Store Departments of Calcutta, Madras and Bombay, there is scarcely any demand for the article in India.

Exported from Western Coast.

The drug collected in Malabar finds an outlet in the ports of Calicut and Tellicherry. That from North Malabar is shipped at Tellicherry, while that from South Malabar (including the Nilambur forests and the Wynaad), Coimbatore and the Nilgiris would be shipped at Calicut. The Native State of Travancore exports its produce through Cochin and Alleppy, while gum collected in South Kanara would be despatched from Mangalore. Coasting steamers and country sailing boats called *bugalows* collect products at all the Travancore and Malabar ports and convey them to Bombay. The trade is in the hands of European and native firms and would account for so much of the kino being called "Cochin grain," as Cochin is the principal port of call, though not necessarily the port at which the kino is shipped.

Origin of term "Cochin grain."

The drug is always exported in a dried state, since it has been found by experience that it is quite unsaleable in the fluid condition.

The last few years have witnessed a great fluctuation in the price of kino in the London drug market.

Advantages of a local market.

In October 1874 the price of kino was quoted in London at £3 to £5 per cwt. (6·4*d.* to 10·7*d.* per ℔). In 20 years afterwards, it suddenly rose to £20 to 30 per cwt. (3*s.* 6*d.* to 5*s.* 4*d.* per ℔ and then to 16*s.* to 17*s.* per ℔, at which price it remained for sometime.

In March 1894, Dr. J. Parker, the Medical Store-keeper, Bombay, found he was unable to obtain kino in the local market in sufficient quantity and at a reasonable rate, and accordingly entered into negotiations with the District Forest Officer, North Malabar. Mr. Marshall, the Forest Officer, undertook to supply the article to the Medical depôt to the extent required and at the rate of 6 to 8 annas per ℔ in the dried state inclusive of all charges. The estimated annual requirement of kino by the Medical Department of India is about 300℔, which at 8 annas per ℔ costs Rs. 150. Were the drug on the other hand purchased from England, where it is not produced, at the high cost of Rs. 17 per ℔, the price would amount to Rs. 4,371, at 1*s.* 2*d.* exchange.

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Malabar Kino: Its Collection.

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During 1896 the price of kino in London declined to 12*s.* and 11*s.* per lb, although many holders of the gum held out for higher prices. The result was that the drug became very much neglected and the stocks remained unsold. COMMERCE IN KINO. Prices in 1896.

In 1897 and 1898 very slight depression was noticed in the market; the price for genuine "Cochin" grain was 10*s.* per lb, and it was reported that there was a scarcity of the true kino. 1897-98.

During 1899 there was a remarkable fall in the value, and the prices realised for Cochin gum as the year advanced were 10*s.*, 8*s.*, 7*s.* 6*d.*, 6*s.*, 4*s.* 6*d.*, 3*s.*, and 2*s.* The deliveries were good at the end of the year, and the large stocks became greatly reduced. The lowering of the value continued in 1900 and in one of the last reports (May 26th, 1900) it is stated "6 cases Cochin sold very cheaply at 1*s.* per lb." *1899.* 1900.

This most desirable result of reducing the price of kino to its normal valuation has no doubt been attained by the reasonable action of the Forest Department in India.

The two following reports by Professor Wyndham R. Dunstan, F.R.S., Sec.C.S., Director of the Scientific Department, on samples of Indian kino sent to the Imperial Institute in 1898, serve to illustrate the commercial position of kino:— Report from Imperial Institute.

REPORT I.

This sample was received with Dr. Watt's letter of April 29th, 1898, having been forwarded by the Inspector General of Forests to the Government of India with a letter dated the 17th March 1898. In the letter of the Inspector General it is stated that the kino from North Malabar is probably of first-rate quality and likely to command a high price in the English market, although samples which were sent to a firm of manufacturing chemists in London had not been reported on favourably.

The present sample shows all the characteristics of the kino prescribed for use in medicine in the last edition (1898) of the British Pharmacopœia. In order to obtain reliable information as to its probable commercial value, a part of the sample was submitted to a well-known firm in the city who deal largely in this material. They report that the substance is genuine kino of excellent quality. With reference to its commercial value, they make the following statement, which shows that there have been great fluctuations in the Kino of excellent quality.

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COMMERCE IN KINO.

price of this drug within recent years. About seven years ago several hundredweights were sold at the rate of 37*s.* 6*d.*, that is, for about 4*d.* per ℔. After the drug had been in stock for nearly two years, most of it was re-sold for £16 a hundredweight, that is, about 2*s.* 10*d.* a ℔. Somewhat later the drug became very scarce and the price gradually rose to 16*s.* per ℔. At the present time the price is still high, kino having been sold for 13*s.* per ℔ within the last few weeks. If, however, any large quantity of the drug were put on to the market, the probability is that the price would again fall to its average value of from 6*d.* to 1*s.* a pound. Having regard to the facts stated in Dr. Watt's letter that kino can be profitably collected at a cost of 8 annas per ℔, and to the statements of the commercial experts referred to above, the most desirable course for the present would seem to be to place relatively small parcels of the drug periodically on the English market, without, however, greatly augmenting the exports to this country. If necessary, this Department would be glad to assist the Inspector General of Forests in placing consignments with trustworthy brokers in this country.

Fluctuation of the market.

REPORT II.

Second Report

This sample of kino, from Pterocarpus Marsupium, grown in the Chanda Division, Central Provinces, is that referred to in Dr. Watt's letter (F. S. No. 3039—43, dated 17th November 1898). In order to compare this sample of kino with the kino derived from the Malabar forests in Madras, a chemical analysis of it has been made with the following results:—

Moisture	16·23 per cent.
Substances insoluble in water . .	10·28 „
Tannin (absorbed by hide powder) .	84·69 „

From these results it is clear that the Chanda kino has very much the same composition as that from Malabar.

Inferiority due to appearance.

Although the kino answers all the tests of the British Pharmacopœia, it is very inferior to the best kino in appearance. The fragments are smaller, duller, and darker in colour, which will probably detract from the commercial value. It is probable that these defects are due chiefly, if not entirely, to careless preparation, especially from overheating in drying the material.

I have already discussed the commercial position of kino in a previous report, dated 14th June 1898, and it still commands a high

price in the English market. It would therefore seem to be worth while to submit for examination another sample of Chanda kino more carefully prepared. COMMERCE IN KINO.

I may add that a commercial expert, whom I consulted on the general question of kino, suggested that it would be more profitable to the producers if Indian kino of uniform quality were sent to England and consigned to one drug broker only. If this were done it is stated that a better price would be obtained for the material. It is thought that so long as indiscriminate shipments are made by any one, and forwarded to various brokers in this country, that the price of kino will fluctuate very greatly, and may on some occasions fall as low as 37*s.* 6*d.* per cwt. Remedies for improving the market.

Dye and Tan.—The bark is occasionally employed for dyeing. Mr. (now Sir Thomas) Wardle, of Leek, found it to contain a brownish-red colouring matter, which produced reddish-fawn colours with tassar silk. The gum might also be used for this purpose if it could be procured cheap enough. The gum is also used in the manufacture of certain wines, and it is believed that most of the kino now exported is used in this connection. DYEING.

The bark is used for its astringent properties in the territory of Goa; and a decoction of the bark has been forwarded from Coorg as a desirable tan liquor. A sample of the thick bark (Register No. 10585) taken from trees in Chanda, Central Provinces, had the following composition:— Tanning material.

Tannic acid	5·4
Water extract	7·0
Moisture	10·2
Ash	12·9

The proportion of water extract in the bark is low, but the percentage of tannic acid in the extract, estimated by means of hide powder, is 77·1.

Medicine.—Rumphius is perhaps the first writer on the East to notice the medicinal properties of the gum. He remarks that the [illegible] MEDICAL PROPERTIES OF KINO.

[illegible]

Marsupium on the Coromandel Coast, and relates that the bark and gum are supposed by the natives to have virtues in tooth-ache. The exudation from a species of Pterocarpus called draco growing in

P. 1370-80.

MEDICAL PROPERTIES OF KINO.

A powerful astringent.

Java, yields red gum which is considered tonic. Dr. Ainslie defines kino as a powerful astringent, and employed with success in *fluor albus*, chronic diarrhœa, and uterine and intestinal hæmorrhages. That from Malabar, however, is chiefly reserved for the European market, and Butea or *Palas* kino is employed in native practice. From whatever source obtained, kino is milder in its action than catechu, probably on account of the phlobaphene it contains, and is, therefore, better adapted for children and delicate patients.

OTHER USES OF THE TREE.

Fodder.

Fodder.—The leaves are an excellent fodder for cattle and goats, and are much in demand; indeed, cattle-keepers are said to often do great damage to the trees.

Green manure.

Manure.—The leaves of this tree are reported by Mr. Mollison to be especially valuable as a manure. An analysis of the green leaves and twigs made by Dr. Leather shows that they contain 21·23 per cent. of dry matter consisting of 19·58 per cent. of organic substance, 0·53 per cent. of potash, 0·05 per cent. of phosphoric acid, and 0·45 per cent. of nitrogen. The leaves also possess an astringent principle which according to Mr. Mollison would repel or destroy insects and grubs harmful to growing crops.

Timber.

Timber.—Sapwood small; heartwood brown, with darker streaks, very hard, durable, seasons well, and takes a fine polish; it is full of red gum resin and stains, yellow when damp; weight 47lb to 52lb per cubic foot.

Suitable for out-door work.

Vengai affords an invaluable timber in Western and Southern India; being unaffected by the heat of the sun or dampness, it is suitable for out-door or in-door work. Owing to the large amount of resinous matter it contains it is not attacked by white ants, and other insects. It has a good fracture, exhibiting a wiry splinter, and the wood is eminently suited for ordnance requisites. It is much used for door and window frames, posts and beams, furniture, agricultural implements, cart and boat building; and has also been employed for sleepers. Twenty-five sleepers, which had been down seven to eight years on the Mysore State Railway, were found, when taken up, to comprise nine good, eleven still servicable, and five bad; sleepers of this timber have also been used to a certain extent on the Holkar and Neemuch and other lines (*Gamble*).

Used for railway sleepers.

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G. I. C. P. O.—No. 1329 R. & A.—14-11-1901.—2,230.—B. N. D.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series

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This sheet and the title-page may be removed when the subject-matter is filed in its proper place according to the letter and number shown at the bottom of each page.

THE

AGRICULTURAL LEDGER.

1901 No. 12.

AFRIDI WAX CLOTH.

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. II., C. 633-36.*]

Afridi Wax Cloth and the Chief Ingredient (Carthamus Oxyacantha oil) used in its manufacture: *A useful new waterproofing material.—*
By George Watt, M.B., C.M., C.I.E., etc., *Reporter on Economic Products to the Government of India, assisted by* D. Hooper, F.L.S., F.C.S.

The objects of THE AGRICULTURAL LEDGER are :—

(1) To provide information connected with agriculture or with economic products in a form which will admit of its ready transfer to ledgers;

(2) To secure the maintenance of uniform ledgers (on the plan of the Dictionary) in all offices concerned in agricultural subjects throughout India, so that references to ledger entries made in any report or publication may be readily utilised in all offices where ledgers are kept;

(3) To admit of the circulation, in convenient form, of information on any subject connected with agriculture or economic products to officials or other persons interested therein;

(4) To secure a connection between all papers of interest published on subjects relating to economic products and the official Dictionary of Economic Products. With this object the information published in these Ledgers will uniformly be given under the name and number of the Dictionary article which they more especially amplify. When the subject dealt with has not been taken up in the Dictionary, the position it very possibly would occupy in future issues of that work will be assigned to it.

To facilitate the preparation of an index to THE AGRICULTURAL LEDGER, the following arrangements have been made, commencing with 1900 :—

All papers published will be paged, irrespective of subjects, into an annual volume. The annual paging will be given on the top of the pages. But to permit of a continuation of the classification into the various series hitherto observed, a further folio will be shown at the bottom of the pages. This will be preserved throughout each series and be continued for several years, until in fact sufficient material in each series has been accumulated to constitute a fair sized volume.

At the end of the year a printed index and title-page will be issued for the annual volume, and after a period of, say, five years an index and title-page will be issued for each series. It has been found that many persons subscribe for a certain series only and do not care to receive the others. The new arrangement, while permitting of the formation of an annual volume, will at the same time retain the serial classification.

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Vegetable Product Series No. 67.)
(Oils.)

THE

AGRICULTURAL LEDGER.

1901—No. 12.

AFRIDI WAX-CLOTH.

[...ary of Economic Products, Vol. II, C. 633-36.]

...nd the Chief Ingredient (Carthamus Oxyacantha ... manufacture: *A useful new Waterproofing Material.*—

...ATT, M.B C.M., C.I.E., etc, *Reporter on Economic Products to* ...*nt of India and Officer-in-charge of the Economic and Art* ... *Indian Museum, Calcutta;* assisted by D. HOOPER, F.L.S., F.C.S.

AGRI

...ver, the plant known to botanists as **Carthamus** ...*eb.*, occurs plentifully over the drier and arid tracts ...a. In Peshawar District it is peculiarly prevalent; ...erous clumps of that spinose herb, might be there ...nstituting an objectionable feature of all the grassy ... met with in fair abundance, the seeds (or to be more ... are very generally collected on account of the large ... which they contain. It is this oil which is the chief ...ae Afridi Wax-cloth. CARTHAMUS OXY-ACANTHA.

...*and Cultivated Safflowers.*—It has been thought by ...ts that **Carthamus Oxyacantha** may be the wild ...ultivated safflower, **C. tinctorius.** Certainly the plants ...y much alike, but nevertheless they seem to preserve their ...c distinctions fairly constantly. The seeds of the *wild plant* ...hall, somewhat boat-shaped, thin, dark-coloured and often mot-...while those of the cultivated plant are at least twice as large, ...broadest at the apex, strongly angled and of a uniform pale ...ky-white colour. Wild and Cultivated Safflowers.

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CARTHAMUS OXYACANTHA.

I am not aware of **C. Oxyacantha** having ever been seen under cultivation, nor have I come across a cultivated safflower that could be even open to the suspicion of being derived from the wild stock. Where met with, the cultivated plant is unmistakably **C. tinctorius**, and the wild plant **C. Oxyacantha.** In this connection it may, therefore, be accepted as somewhat significant that the arid tracts of Northern India (the Punjab, Rajputana, Central India and Sind) are by no means the regions of greatest production of safflower.

Races of Cultivated Plant.

Races of Cultivated Plant.—But of the cultivated plant there are two conditions, one grown purely and simply for its flowers—the Safflower Dye of commerce (very largely produced in Bengal and the North-Western Provinces and Oudh)—the other for its oil-yielding seeds—the *Kusum* or Carthamus Oil of commerce (very largely produced in Bombay and the Central Provinces). But while these two conditions seem well understood agriculturally, dried specimens of the plant grown for the one and for the other purpose when preserved in the herbarium are quite indistinguishable. Moreover, several races occur under each of these states, such as with small very hard spinose leaves or with large soft almost non-spinose edible leaves. Some have very narrow hard and sharply spinose bracts, others have very broad almost entire bracts. Still all these conditions would appear to occur with both the oil-yielding and the dye-yielding plants so that no set of characters can be given to separate the groups of races that belong to the dye-yielding or to the oil-yielding series.

Kusum.

In order to ascertain this point specimens have been procured from most districts in India, the result being, as already stated, that no satisfactory classification can be suggested. In the Deccan the oil-yielding plant is generally known as *Sadhi*, and the dye-yielding as *Kusumbyachi*. The former seems as a rule to be a stronger, larger, and more rigidly spinose plant than the latter. So again while speaking of the dye-yielding forms most writers refer to two groups:—

Sadhi. Kusumbyachi.

(*a*) A very spiny form that yields inferior dye but good oil. It is known as *Kutela* in Patna, the *Kati* in Berar and may be the *Sadhi* of the Deccan already mentioned.

(*b*) An almost spineless form known as *Bhuili* in Patna, *Bodki* in Berar, *Murilia* in Azamghar and *Kusumbyachi* in the Deccan. This affords the richest dye but a smaller proportion of oil.

SAFFLOWER OIL.

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3. ***Safflower Oil.***—From the analysis performed in the Chemical Laboratory of the Indian Museum (given under a former paragraph) it may be inferred that there is very little difference between the oil of the wild and of the cultivated safflowers. But so far as can be learned, the workers in Afridi Wax-cloth use the oil of the wild plant only. This circumstance may, however, be due entirely to the cultivated oil not being readily procurable in Northern India. In fact, from practical experiments conducted under my supervision it would seem that the cultivated oil is equally serviceable for the special purposes, for which the wild oil is specially employed. Assuming, therefore, that it is probable that a more extended utilisation of Carthamus oil may take place in the future the occasion would necessarily arise for drawing on the at present limited supplies of Northern India. The cultivated oil can be obtained in all the bazars of the lower provinces. Indeed the supply might easily become important. Bombay is the chief emporium in the present trade, but it would appear that while there is a fairly large export to Europe in the seed, the Indian expressed oil is rarely if ever shipped. This may be due to the fact that it is as a rule very generally adulterated with gingelly oil (Sesamum indicum) an admixture that would very possibly greatly lessen its value for the special purposes that the present paper is intended to set forth.

4. ***Methods of Preparing the Oil.***—According to Mr. W. H. Bingham (the only important writer apparently on this oil) there are two forms of the oil depending on the method pursued in separating it from the seeds:—

(*a*) *Cold Expression.*—After the seeds have been husked they are pressed in an ordinary oil-mill. They are said to yield about 25 per cent. of a clear, yellow, thin, edible oil, and one that burns without giving out anything like so much heat as most other luminants. It is used for culinary purposes (pure or mixed with gingelly), and in that form is said to be an ingredient in Macassar Hair Oil.

(*b*) *Dry Hot Process.*—By this method the seeds are charred so that the oil exudes naturally from them without any pressure being necessary. The process described by Mr. Bingham is briefly as follows —Two earthen pots (*garrahs*) are placed mouth to mouth with a plate between them which has a small hole drilled in the

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PREPARATION OF SAFFLOWER OIL.

centre. The inverted *garrah* is filled with the seeds of safflower, and around (outside) this a fire of charcoal is ignited. The lower pot is kept cool by being buried in the ground, and it is earthed up so as to allow of the fire being arranged around the top *garrah*. The oil drains from the top into the bottom *garrah* as the seeds are gradually charred, the process usually taking well on to an hour. The yield of oil is about one-fourth larger than that by cold expression, but it is useless both for burning purposes or for food. It has in fact acquired a new property and been converted into a substance very serviceable for greasing well-ropes, leather well-buckets, etc. —purposes for which the cold drawn oil is quite unsuited. In other words, the oil has been converted into what is known as *roghan*—a substance employed to prevent leather from hardening, on its being exposed to the action of water or of a damp atmosphere.

The Peshawar Method of Manufacture of Roghan.

5. ***The Peshawar Method of Manufacture of Roghan and Tradition as to Discovery.***—In Peshawar a very different process is adopted, from that just detailed, for the manufacture of *roghan*. The oil contained in the seeds of the wild safflower (there known as *polli*), is in the first instance expressed by the cold process. In this state the oil is useless for the peculiar manufacture for which it is intended. It is accordingly subjected to a treatment that would appear in some respects to simulate the result obtained by the charred oil process. It is placed in earthen vessels and boiled continuously for 12 hours. The vessels are so fitted (in mud fire-places), that it is not possible for a flame to reach the boiling liquid. If a flame should reach it, the entire quantity would be consumed in a remarkably short time, since the heated oil is inflammable. The temperature of the boiling liquid is, however, kept low and uniform. After it has boiled for some time it begins to emit volumes of a white pungent vapour, so exceedingly disagreeable that the manufacturers of this article, in the town of Peshawar, are compelled to conduct their business under special license, and in a place assigned to them outside municipal limits. On the oil being cooked to the required extent, and while still boiling hot, it is thrown into large shallow trays containing cold water. Under this treatment it swells up into a thick jelly-like substance known as *roghan*, and in that condition it

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is stored in old kerosene oil tins until required by the manufacturers of the Afridi wax-cloth. ROGHAN PREPARED FROM THE OIL.

Under the paragraph devoted to the chemistry of this substance, will be explained the nature of the vapour that is driven off by boiling, and the object attained by throwing the boiled oil into cold water. Soldered down in tins it is then exported all over India to be used by the Afridi wax-cloth workers in Lahore, Delhi, Multan, Bombay or Calcutta. In Peshawar and in Peshawar alone apparently is the secret known of the material used and method of preparation of the *roghan* so essential an ingredient in the paint which they employ.

Hist. Disc.

History of Discovery.—When questioned as to how this curious method of preparing the oil into *roghan* could have been made, I was informed by one of the oldest Afridi workers in Peshawar, that the art had been in existence in his country from time immemorial. There was a tradition regarding the discovery that ran as follows:—Once upon a time an oil vendor's house took fire and a large quantity of *polli* oil being preserved therein it turned into a paste owing to the very great heat of the conflagration. A sage named Nakshaband seeing the distress of the oil merchant examined the paste and taking some on the tip of his finger showed the way in which it might be painted on to cloth.

Phy. Prop. of Ro

6. ***Physical properties of Roghan.***—If the finger be first moistened and then plunged into the thick *roghan* it will be found that the finger is in no way soiled, but if it be not first moistened the *roghan* adheres and is somewhat difficult to remove. The *roghan* when quite fresh is a thick adhesive dark-brown coloured jelly-like substance which in thin layers is almost transparent. When exposed to the air for a few hours it forms on the surface a firm shining skin with the consistence almost of thin leather. If exposed for a still longer period, say, a few weeks, the *roghan* becomes very much more liquid and changes into a dull yellow opaque colour. It seems to part with the water with which it united when thrown into the shallow earthen basins above described. If not thrown into water the boiled oil or *roghan* never turns opaque but sets in a few days into a firm hard leathery substance.

Opinions Auth.

7. ***Opinions of authors.***—During a brief visit to Peshawar and in consequence of the very enlightened and generous assistance rendered me by Mr. E. W. Graham Roe, Secretary and Engineer to the Municipality, I was enabled to witness the manufacture of *roghan* in

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AFRIDI Wax-cloth. Afridi Wax-cloth and the Chief Ingredient (Carthamus

PREVIOUS KNOWLEDGE REGARDING WAX-CLOTH.

every stage. In fact Mr. Roe (with whom I stayed while in Peshawar) arranged with the workmen to bring a small quantity of the oil and to boil it in his garden, so that from time to time, I might be able to study the process, experience something of the inconvenience of the trade, and witness the change that takes place on the boiling oil being dashed into cold water. But for Mr. Roe's great personal influence and intimate knowledge both of the workers and of their language I could never have obtained the information I was so fortunate as to thus secure.

Very little has been written on the subject of the Afridi wax-cloth but practically every statement made heretofore may be said to have been inaccurate. I mention this circumstance because up to the date of my being able to secure the co-operation of Mr. Roe, the manufacture of Peshawar *roghan* had apparently been kept a trade secret. During a visit to one of the manufacturers' shops, I picked up a few seeds and recognising these as the seeds of **Carthamus Oxyacantha,** I affirmed that the *roghan* of which they spoke so mysteriously was made from these seeds. This seemed to so startle the manufacturers that they resolved to show me the entire process but no one was more surprised than myself for I had no sort of suspicion that my guess was likely to be correct. To make quite sure, however, that my determination of the seed was right, I offered a small reward to any one who would bring me a specimen of the *polli* plant. Shortly, thereafter, I was presented with a small twig of **Carthamus Oxyacantha,** so that there was left no room for doubt. Having subsequently (as just stated) personally witnessed each of the stages, from the expression of the cold drawn oil to the completed *roghan,* I am in a position to affirm that the Peshawar *roghan* is made from wild safflower oil and in the manner already briefly described.

Determination of Botanical Source.

Dr. Stocks' Observations

It is, however, significant that writers on Indian economic products did not chance to make this discovery years ago. Stocks, for examples, speaking of Sind and of the cultivation of the *Powari-jo-bij* or **Carthamus tinctorius** says:—

"The oil of the safflower seed is extracted by a wooden pestle working in a wooden mortar and driven by oxen or camels. The residuum or oil-cake is called *Khur* and is universally used for oxen, camels, goats and sheep. The *Powari-jo-bij* is also called *Khoinbo-jo-bij, Koinbo* being the name of the plant. There is a wild seed which is also called *Powari* but is of no use."

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PREVIOUS KNOWLEDGE REGARDING WAX CLOTH.

Stocks was an exceedingly careful observer and it is thus curious that while describing the oil of the cultivated plant he should have failed to learn about the oil of the wild species. Stewart (*Punjab Plants*) mentions the wild plant as affording an oil but nothing further. Still more significant is it that neither Mr. H. Baden-Powell, C.I.E., nor Mr. J. Lockwood Kipling, C.I.E., who each lived for so many years in the Punjab, should have missed learning the special use of this wild plant. The former in his *Punjab Products* (*page 422*) alludes to the oil of both the cultivated and wild plant (which he calls *Karar*) but neither in that passage nor in any other, does he mention the fact of the Afridi wax-cloth being ornamented by a preparation of *polli* oil. The latter on several occasions described the Peshawar Afridi-work but never seems to have investigated the materials employed by these artisans. The following account by Mr. Kipling is fairly characteristic of the opinions that prevailed till very recently:—

Mr. J. L. Kipling's Description.

"A curiosity of local production in Peshawar is a kind of raised colour painting on cotton fabrics. A pattern necessarily of a large and open kind, is first painted on the cloth in lac or some similar sticky substance. The forms seem to be afterwards loaded up with a brush full of resinous colour, generally red, so that the pattern is in low relief. Sometimes powdered mica is sprinkled over the lac to give it a shimmer. These fabrics, though they might resist a shower, could scarcely be washed. They are unlike anything else made in the Province. When new they have a distinct odour of mutton fat which may possibly be mixed with the thick colour. When the pattern is in tones of yellowish red, on dark *nila* or indigo blue cloth, the effect is rich and good but on lighter colours it is less satisfactory."

This description, (from the observations that follow) will be seen to be incorrect. There is for example no "loading up with a brush full of resinous colour." The colours are mixed with the *roghan* and applied direct, but under no circumstance is a brush ever used. So again Mr. Kipling's further suggestion that these fabrics cannot be washed is equally wide of the mark for they most certainly can be.

Manipulation of Afridi Wax-cloth.

S. Manipulation of Afridi Wax-cloth.—Before proceeding to discuss the chemical and commercial aspects of the *polli* oil and *roghan* it may perhaps be the preferable course to give a brief description of the manufacture of the goods generally designated Afridi wax-cloth. It may have been observed, from the remarks

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MANUFACTURE.

already made, that in this industry the *roghan* is exclusively employed.

Colouring Materials.

Colouring Materials.—But in every instance it is mixed with colouring materials mostly of a mineral nature. Yellow is obtained by mixing the *roghan* with a fine powder of yellow arsenic (orpiment); red with red lead; white with white lead (or the white powder sold as such which often contains a large admixture of barium sulphate, one sample affording as much as 83 parts per hundred); silveriness by white coloured *roghan* dusted over the surface with powdered mica; and gold with gold leaf or the imitation gold or silver powder imported from Europe; blue with indigo (the only vegetable pigment apparently employed); and green with orpiment and indigo. Fine powdered lime is used to reduce the stickiness of the preparation when found to be too moist.

So far as I have been able to discover, aniline dyes have not as yet been introduced to this industry as has most unfortunately been the case with lac-turnery and lac-varnishing.

The *roghan* is worked up on a smooth stone with the colouring ingredients. It is generally prepared as required, since if kept exposed to the air for any length of time, the coloured *roghan* tends to become moist and to necessitate a larger quantity of lime being subsequently applied than is deemed desirable.

The Artisan and his Productions.

The Artisan and his Productions.—The operators in this curious industry seem invariably to be Afridis although in the towns of India the owners of the shops in which they are employed need not be so. When questioned in Simla, Lahore, Calcutta and other towns, as to the substance used by them, the Afridis were very nearly invariably found to either refuse to reply or to profess ignorance, and as a rule gave but one piece of information namely that the material came from Peshawar. It was this circumstance very largely that induced me to visit that most interesting frontier city.

A Lady's Dress.

A Lady's Dress.—In the Afridi country the art has from very ancient times been practised in the ornamentation of certain garments worn by the females. These may be said to consist of a frock with bodice and sleeves, also a shawl to be thrown over the shoulders They are mostly in thick coarse cotton cloth elaborately coloured with *roghan*. The original designs employed in ornamenting these articles of attire are mostly in red, yellow and white, and so elaborate as to become (from the western standpoint) curious

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MANUFACTURE. Dress Material.

but hardly artistic. Mr. J. Lockwood Kipling speaks of the designs as "bold semi-barbaric." In the passage already quoted he says "when the pattern is in tones of yellowish red on dark *nila* or indigo blue cloth, the effect is rich and good but on lighter colours it is less satisfactory." From their great weight, wax-cloth garments can neither hang elegantly nor be comfortable to the wearer. A lady's dress, procured by me in Peshawar, and now in the Indian Museum (which consists of a simple skirt, a bodice and wide sleeves), weighs 11 lbs. The shawl which is thrown over the head weighs 2 lbs. 2 oz. so that the total weight of these articles of dress alone comes to 13 lbs. 2 oz.

Patterns Described.

Sample No. 1 shows the characteristic pattern of these Afridi dresses, and it consists of floral ornamentations, for the most part in red and yellow, on a coarse blue cloth. The design most commonly met with is known by the Afridi name *Mal-khosai*, and in Peshawar as *Maithri* The border pattern is in Afridi known as *Kagai-leekai*, and in Peshawar as *Ding*. The *Mal-khosai* somewhat resembles the separated flowers of Nyctanthes Arbor-tristis laid sideways all over the fabric and as close together as possible. When a somewhat similar floral-pattern occurs, but without the stalk or corolla-tube, its Afridi name is *Panai-Rakh*, a pattern which in Peshawar is called *Girad-gul*. The sleeve of the frock is often ornamented with checkered patterns known in Afridi as *Jal*, and in Peshawar as *Sutranjee*. These designs collectively may perhaps be accepted as recalling the ornamentations employed in the *phulkaris* or the elaborately embroidered female dresses worn in the Punjab plains.

Having referred to and illustrated with an actual sample, what may be called the prototype of Afridi wax-cloth ornamentations, an account of how this is accomplished may now be given.

The Operation.

The Operation.—The artisan takes in the palm of his left hand a lump of the coloured *roghan* about the size of a pigeon's egg. He very often, but not invariably, wears a leathern shield across the hand upon which the *roghan* is placed. In his right hand he holds a short iron style, about 6 inches long, which is pointed at one end. With the pointed end he works up the *roghan* and draws it out into fine threads. If it is too moist to draw out properly he works into it a small quantity of finely powdered lime. When he has succeeded to draw it out properly and regards the material as in a workable state, the end dangling from the small quantity on the style is applied to

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MANUFACTURE.

Applying the Pattern.

the cloth and the thread deftly wound this way and that, all the while being slightly drawn finer and finer. The main divisions of the pattern may have been previously marked or outlined with chalk on the fabric but the details are worked up without anything to guide the operator and, in the commoner designs, such as that of the Afridi dress cloth (*Mal-khosai* or *Panai-rakh*), it is never outlined in any way.

The rapidity and accuracy with which the pattern is worked up by threads of plastic *roghan* has to be seen to be appreciated and understood. The style is charged time after time from the store on the left hand and the little thickness or slightly rounded portion formed where each thread commences is most artistically utilised. The skilled artist can work from right to left with as much ease as from left to right, hence just as in penmanship, the thick downward strokes and the fine upward hair lines are each made to occur in their proper places.

Adhesion of the Coloured Roghan.

Adhesion of the Coloured Roghan.—No sooner has a line of the *roghan* been deposited on the cloth than the moistened tip of the finger is dabbed all along it. This has the effect of causing the *roghan* to sink into the texture of the cloth and to firmly adhere. In a very short time it dries or hardens and becomes quite permanent so that fabrics ornamented in this way may even be washed without materially disturbing the pattern. The combination of an oily substance with a metallic pigment and with lime causes the material to dry most effectually, but much depends on the skill displayed in mixing and working up these ingredients. Sometimes also powdered mica (*abrac*) is dusted over the winding lines of *roghan* to give the pattern a silvery gloss, or gold leaf or imitation gold and silver powders may be similarly applied. In brushing or washing wax-cloth fabrics the imperfectly adherent particles of mica or gold may be removed but the bulk will remain and the coloured *roghan* itself can hardly be removed by ordinary treatment and is not even softened by the heat to which the fabrics are likely to be subjected. The fading of the colours, that sometimes takes place, seems to be due to the use of inferior pigments such as white lead that consists mainly of barium sulphate, and more especially to the presence of sulphur in the materials employed.

Elaboration of the Design.

Elaboration of the Design.—When solid patches of colour, such as the leaves or petals of flowers or the bodies of birds have to be made, the style with its dangling thread is made to travel many

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times over the assigned space but always in the same direction, not backwards and forwards; the perfectly parallel lines of *roghan* thus laid down are by the moistened finger compressed into the desired patches. Indeed so expert are the workers that all trace of the original parallel lines, of which such patches are built up, completely disappears. Where two or more colours have to be given the operator usually applies all the patches and lines required of one colour before he proceeds to use the second or the third. The half finished table-cloth or fire-screen may in consequence often appear a most bewildering production from which it is difficult to discover the actual pattern in the operator's mind.

MANUFACTURE.

The Patterns in two or more Colours.

10. *Modern Developments.*—During the past 20 years or so a modern development of this industry has been gaining rapidly in popular favour. This is one of the many instances of the adaptation of Indian industries to the requirements of the Europeans resident in this country and to the export trade to Europe. Obviously the art could not be adapted to the conditions of European dress. But the ever increasing demand for household drapings gave a ready outlet for the Afridi artisan's skill. Table-cloths, curtains, fire-place draperies and such like fabrics, could be beautifully and cheaply ornamented with the coloured *roghan.* But at once apparently it was recognised that the over-burdened, though time-honoured designs, employed in Afridi dresses were not adaptable to such new purposes. The older patterns may be described as consisting mainly of isolated trifoliate clusters imprinted as closely as possible all over the skirt but assorted more or less in parallel lines. The sleeves and bodices, moreover, are often even more heavily ornamented, namely, in squares or patches of almost any pattern and without definite relationship—a medley of colour that recalls the old-fashioned "sampler."

Modern Developments.

Open Floral Scrolls.—Obviously decorative designs of such a nature could hardly be adapted to the modern demand and accordingly numerous developments of a graceful open floral scroll (Sample No. 2) were introduced in which easy flowing curved lines, tendrils and leaves, encircle petaloid rosettes, each alternate section being inverted in a pleasing symmetry. Curiously enough I could obtain no Afridi name for this pattern though it is known to the Peshawar workers as *chow-patra*, the border design or fret being the *chow-phulia.* In some respects the

Open Floral Scrolls.

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MANUFACTURE.

Floral Patterns.

chowpatra has the feeling of Grecian decorative art. But it is by no means certain that these designs are entirely foreign to the Afridis even although the persons consulted admitted there were no purely Afridi names for them. Besides ornamenting female garments (in the manner described) the Afridi has always produced highly ornate tobacco pouches and other such small articles which have apparently from time immemorial been illuminated with coloured *roghan* in designs that might easily have given birth to the *chow-patra* of the modern European trade The ease and rapidity with which hundreds of artisans threw themselves into this new traffic would seem to point conclusively to the designs thus employed having been by no means of foreign origin.

The fabric used in the European goods is usually a coarse cotton cloth dyed in dark shades of blue, green or brick red, with ornamentations either in gold or silvery-white but rarely mixed colours. In the case of curtains it is usual for the main conception to be that of a Muhammedan praying carpet. The central panel is very often elaborately worked up from a " cone-pattern " placed near the lower extremity. The border and triangular top portions are in smaller but corresponding designs, the frets frequently being elaborated from a pinnate foliage.

Japanese Designs.

Japanese Designs.—The effect is distinctly rich and graceful, but unfortunately the spirit of change or rather of adaptation to the caprice of demand has been imbibed by the Afridi artisans. In consequence a further development has taken place in the production of curtains and screens in imitation of Japanese work. Storks are placed in water from which date-palms and copiously-flowering grasses, bull-rushes, etc., are growing, or they are dispersed here and there in every conceivable attitude and size or are copiously intermixed with swallows and butterflies. All idea of conventional ornamentation has been destroyed and perspective and proportion very nearly entirely lost sight of. Mixed colours are also freely employed and light shades of cloth only too often used. Still the effect cannot be said to be altogether unpleasing and the demand for this class of goods has during the past few years increased rapidly. But even in these Japanese designs, the imprint of the Afridi art instinct cannot be said to be altogether absent The use of the date-palm is certainly not Japanese, and the grasses portrayed and the frets of pinnate foliage employed would all appear

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to be purely indigenous. That the coloured, more especially the gold stained, *roghan* of Peshawar, can lend itself to such treatment must be admitted as evidence of limitless future developments.

Old Specimens of Afridi Wax-cloth.

11. ***Old Specimens of Afridi Wax-cloth.***—While in Peshawar I enquired at the manufacturers of wax-cloth if any authentically old samples of this work could be found. An onlooker said he had a picture in his house that he believed to be very old—he had known it all his life. This was duly produced and purchased by me for the Indian Museum. It is a small square of dark blue cloth on which is represented an Afridi peasant woman dressed in the characteristic frock already described. The woman is carrying on her head a bundle of fire-wood and is in the act of passing between two crudely drawn branched trees, while overhead are two very graceful birds in pale green, the wing feathers fading into pink and golden tips. The subject and design is so essentially Afridi that this picture must be accepted as most probably in no way connected with the Japanese adaptations just mentioned, although the presence of birds is most significant.

The General Use of Drying Oils is not Indian.

Drying Oils hardly known in India.—It would thus seem highly probable that pictures for household ornamentation were not unknown prior to any of the modern developments of this industry. This circumstance may perhaps be admitted as curiously interesting since the use of a drying oil in paints such as linseed or safflower has never apparently been known or practised by the Asiatic races. In the Agricultural Ledger (No 9 of 1901) I have described the system of painting in water colours, varnished over with lac or copal, which in India takes the place of painting in oil colours. The employment of roghan along with pigments as here detailed, is perhaps the only really ancient indigenous use of a drying oil known in India.

Old Pictorial Designs.

Pinnate Foliage.—But to return to the subject of old examples of Afridi wax-cloth. I have to record that subsequent to the date of my visit to Peshawar Mr. Graham Roe was good enough to make a careful search for old specimens. He also persuaded some of the Afridis in Peshawar to send to their homes for good examples. The result has proved highly satisfactory. The Indian Museum in Calcutta now possesses a most instructive series of beautiful designs and of such a varied character that a school of decorative art might easily take its birth from their careful study and development. The

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majority of these designs are in the open graceful scroll (designated *chow-patra*), but in which the use of pinnate foliage may be said to occur so frequently as to become a special feature. But in none of these is the date-palm portrayed—the tree of life according to some writers of the Arabic races—unless the pinnate foliage be regarded as traceable to that type.

ROGHAN. Other Uses of Roghan.

12. *Other uses of Roghan.*—Most writers have alluded to the fact that the *roghan* or boiled oil of safflower is a valuable lubricant for leather and the leathern buckets used at wells. It prevents the leather from hardening and cracking. This circumstance has apparently led some writers to speak of it as a water-proofing material. But I am not aware of any person having tested its possible use as a direct water-proofing material until the experiments that are presently to be detailed were undertaken by Mr. D. Hooper at my request in the chemical laboratory attached to the Indian Museum.

A Cement for Glass and Stone-ware.

A cement for glass and stone-ware.—While investigating this substance it was found by me accidently that a thin layer of fresh *roghan* was an exceedingly convenient and powerful cement for glass and stone-ware. If the surfaces intended to be joined together are first cleaned and then coated with *roghan*, the cement will set in a few hours and become so firm that the surfaces cannot again be separated unless turpentine be allowed to soak into the layer of cement. In consequence of this discovery *roghan* was immediately adopted in the Economic and Art Museum as the cement to be used in fastening the flat glass covers required for the jars containing exhibition specimens, as also for all other such purposes where cement was necessary. In no instance has it been found to fail, except when the *roghan* had been kept for a very long time exposed to the air and had become completely opaque. But even when this has occurred all that is necessary to restore the *roghan* to its useful condition is to once more boil it and throw the boiled jelly into cold water.

CHEMISTRY OF THE OILS.

13. *Chemistry of polli oil and roghan.*—From the study of the industry in Peshawar more especially the firm skin which the boiled oil formed, and the circumstance that the *roghan* would not adhere to the moistened tip of the finger, I was led to suspect that one or other of these substances might prove of value as a water-proofing material. I accordingly directed Mr. D. Hooper to take up (in the Museum Chemical Laboratory) the investigation of this oil and its various preparations, with a view to discover if these might

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CHEMISTRY OF OIL.

prove of value to European commerce, more especially as substitutes for India rubber. Mr. Hooper accordingly gave attention to this subject and although his results and opinions cannot be regarded as having as yet attained any finality it may be useful to give them here so far as they have gone:—

Comparative Composition.

Comparative Composition.—"The seeds of **Carthamus tinctorius**, (a plant at one time cultivated very largely for its dye), yield an oil useful for edible purposes, for medicine and for burning. The seeds of **C. Oxyacantha** also afford a very similar oil."

"The composition of the two kinds of seeds may be represented as follows:—

	Kusum.	*Polli.*
Fixed oil	25·42	20·24
Water	6·74	6·40
Ash	2·82	6·02
Organic matters	65·00	67·34
	100·00	100·00

"The cultivated plant is somewhat superior as an oil-yielder and the seeds of the wild plant, moreover, contain more mineral matter.

Experiments of Messrs. Le Sueur and Crossley.

"At the request of the Director of the Scientific Department of the Imperial Institute an extensive series of edible oils was collected by the Reporter on Economic Products and sent to London for examination. This embraced some 13 samples of Carthamus oil. These were examined by Messrs. Le Sueur and Crossley and the results published in *The Agricultural Ledger* (*No. 12 of 1899*). The samples examined included 11 of *Kusum oil*, (derived by cold expression), one by the hot extraction method, and a single specimen of *Polli* oil. Unfortunately at the time these samples were issued, Dr. Watt had not made his investigations in Peshawar and accordingly no samples of the *roghan* were furnished for comparative examination.

"The practical information learned from these investigations may be set forth as follows:—

(1) **Carthamus tinctorius**, oil cold expressed—drying.
(2) **Carthamus tinctorius**, oil distilled—non-drying.
(3) **Carthamus Oxyacantha**, oil cold expressed—semi-drying.

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AFRIDI Wax-cloth. Afridi Wax-cloth and the Chief Ingredient (Carthamus

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or they may be exhibited in more detail thus :—

Sp Gr. at 15 5° C.	Acid Value.		Saponification Value.	Iodine Value.	Insoluble Fatty Acids	Rotation in 20 c. m tube.	Ratio of viscosity to water at 70° F
	As K.H.O	As Oleic Acid.					
1 ·9231 to ·9280	76 to 20·02	·19 to 5·04	192·5 to 186 6	138 6 to 144·4	95·30	+ 4′ to 14′	9 57 to 10·81
2 ·9634	...	...	188 0	128 93	...	...	...
3 9270	3·66	·92	189·4	135·49	95 44	+ 7′	11·57

"The samples under No. 1 include all the different qualities of safflower oil prepared in India by cold expression (*paragraph 4a*). No. 2 was prepared by the hot extraction method which is a form of downward distillation resulting in a dark coloured almost black oil with a tar-like smell (*paragraph 4b*). Its specific gravity is higher and its iodine value lower than the determinations found in the naturally expressed oils. It will be noticed that the oil from the wild plant does not differ materially from that of the cultivated species.

Mr Le Sueur's Results.

"Mr. H. R Le Sueur, B Sc., continued his investigation into the physical and chemical properties of the oil of **Carthamus tinctorius**, and communicated the results to the *Society of Chemical Industry* (London, February 1900). The following may be given as a very brief review of his final conclusions :—

"The drying properties of Carthamus oil are undoubted, and in the paper an examination is recorded of the nature of the acids contained in that oil in order to render it comparable with linseed oil.

"The saturated acids consist of palmitic acid and stearic acid, separated by Heintz's method of fractional precipitation with Magnesium acetate and fractional crystallisation from absolute alcohol.

"The unsaturated acids were treated according to Hazura's method of oxidation with Potassium permanganate in alkaline solution when dihydrostearic and sativic (tetra-hydroxy-stearic) acids were obtained This proves that oleic and linolic acids are present in the unsaturated acids and from the amounts obtained linolic acid exists in the larger proportion. No linolenic nor isolinolenic acid was detected.

"To understand these results it should be known that linseed oil contains, according to Lewkowitsch, 10 to 15 per cent of glycerides of solid fatty acids—stearic, palmitic and myristic—and 90 to 85 per cent. of liquid glycerides. The liquid fatty acids consist according to Hazura and Grussner of about 5 per cent. of oleic, 15 per cent. of linolic, 15 per cent. of linolenic, and 65 per cent. of isolinolenic acids.

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"The solid and liquid portions of safflower seed oil, therefore, contain some of the identical constituents of linseed *oil*; the *specific gravity* and *iodine* value of the safflower *oil*, however, are not so high as they are in linseed CHEMISTRY OF OIL.

Investigations conducted at the Indian Museum.

"*Properties of the Oil.*—The following chemical examination of the oil actually used in Peshawar for making the peculiar wax-cloths was conducted on the samples furnished by Dr. Watt:—

"The cold expressed oil of wild safflower—*Polli* (Carthamus Oxyacantha) was found to be tasteless, inodorous and to possess a bright yellow colour. The specific gravity was ·9265 at 15°C., and the oil did not congeal when kept for one hour in a mixture of ice and water. The oil, when heated in a shallow vessel, slowly absorbed oxygen from the air, a skin formed over the surface, and eventually it became converted into a jelly, but these changes took place less rapidly than with linseed oil, under the same circumstances. The oil required 19·4 per cent. of potash (KHO) to form a neutral soap which gives a saponification equivalent of 289·1. The amount of free fatty acid obtained by direct weighing was 4·27 per cent., the total fatty acids present was 94·66 per cent. Two estimations of the iodine value afforded the figures 132·9 and 132·4 respectively which is as high as those of poppy seed oil but still below those of linseed oil. The viscosity, taken in relation to water, was 15. The lead soap formed by precipitating the alkaline oleate with lead acetate was for the most part soluble in ether, indicating the presence of oleic or linolic acid in considerable quantity. PROPERTIES OF THE EXPRESSED OIL.

"*Properties of the Boiled Oil.*—The boiled oil of *polli* seeds, or as it is called *roghan*, was thick opaque and of a light-brown colour. It was partially soluble in alcohol and freely in ether and chloroform, with the latter solvent a cloudy solution resulted, owing to the presence of water which was estimated at 3 per cent. The water was evolved when a small portion of the *roghan* was heated in a test tube; after its separation by this method the oil became clear. The density of the boiled oil was ·9729, and it did not congeal in melting ice. When heated in a shallow vessel to test its drying properties, a skin was formed over its surface in 24 hours, but the increase in weight was scarcely perceptible when the exposure to a heated atmosphere was prolonged. The amount of potash to produce a neutral soap was 19·7 per cent The free fatty PROPERTIES OF THE BOILED OIL.

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CARTHAMUS AND LINSEED OIL COMPARED

after careful weighing, were heated constantly at the temperature of boiling water, and each sample was weighed at intervals of 24 hours until it become solid or formed a solid mass.

"100 parts of "Raw" linseed oil at the expiration of 24 hours weighed 101·37; the next day a skin began to form over the surface the weight was 104·16; on the third day it slightly increased to and became 104·67, and remained at this figure until the fifth day when the oil had been converted into a firm jelly.

"100 parts of "Pale boiled" linseed oil thickened in the first 24 hours and increased to 102·95 parts; after the second 24 hours it became pasty and the surface partially dried up to a pellicle, increasing in weight to 103·76; at the end of the third 24 hours the oil was completely solid with no further absorption of oxygen.

"100 parts of "Brown boiled" linseed oil set into a firm jelly within 24 hours, the increase of weight only reaching 101·32 parts.

"The *Carthamus* oil in its natural state very slowly absorbed oxygen up to the second day when 100 parts had increased to 102·24; a pellicle formed on the surface on the fifth day but the thickened oil was still in a fluid condition. A week was necessary before the oil solidified, and even after that time the jelly, although free from "tackiness" was much softer than the desiccated products of linseed oil.

"The *roghan* or boiled oil, on account of the small proportion of water incorporated in it by the native manufacturer, showed no increment of weight after prolonged heating in the water-bath, the small amount of combined water was rapidly dissipated, and a clear, soft, light brown jelly was yielded within 24 hours.

CHEMICAL CHANGES ON BOILING SAFFLOWER OIL.

"*The preparation of Roghan.*—The preparation of *roghan* is thus explained. The naturally expressed oil of wild safflower is heated for several hours until it thickens. On the application of heat the temperature gradually rises, and at 140°C. and upwards, a pungent odour is given off which affects the eyes causing a flow of tears, and producing an acrid suffocating sensation in the throat if inhaled. This is due to a substance named *acrolein* (C_3H_4O.) which is evolved when glycerine or its combinations as glycerides are rapidly heated. The same odour is detected, although in a less degree, when an oil lamp or tallow candle is blown out. Acrolein continues to be given off while the oil rises to a temperature of between 210° and 250°. After about 6 hours the acrolein is given off in less abundance

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CHEMICAL CHANGES ON BOILING SAFFLOWER OIL.

and the oil assumes a darker colour and thicker consistence. After about 10 hours it loses altogether its oleaginous property and becomes sticky at this stage, and while still hot, it is thrown into water, and emulsification ensues in such a manner as to preserve its sticky nature. Otherwise it would form into a jelly as it cooled and cease to flow from any vessel in which it was placed. The *roghan* oil prepared after this manner retains its adhesive properties as long as it is preserved in a convenient vessel, but on exposure to air, such as when it is spread on any cloth material, it solidifies to an insoluble water-proofing compound."

POSSIBLE FUTURE DEVELOP-MENTS.

14. ***Future Developments.***—The results of the investigations briefly detailed may be said to point to the possibility of both the wild and the cultivated carthamus oils being used for many of the purposes to which India rubber is ordinarily put. As a water-proofing material in the preparation of oil-cloths, tarpaulins, and tents or as a material to be used in the manufacture of linoleum it seems to have a distinct claim to careful consideration. For these purposes it would appear to be superior to linseed since it is not so liable to crack and, after being once properly dried, does not soften by heat nor become sticky

Water-proofing cloth

Under my supervision a series of experiments were performed in the laboratory in order to ascertain the most serviceable preparations of this substance to be used in the production of water-proofing sheetings. The cloth employed was an unbleached canvas obligingly supplied by Major-General R. Wace, C.B., Director General of the Ordnance Department. The *roghan* as procured from Peshawar was found to be too thick and adhesive to be applied with a brush. This circumstance was altered to some extent by heating the *roghan* before use, and without any diluent it was found best to spread it over the fabric by means of a spatula. That method was, therefore, pursued and the coated fabric when left for a few hours, was seen to be completely penetrated by the *roghan*. The coating, however, took several days to dry, even when exposed to the hot sun. In the shade it dried, however, more rapidly and manifested to a much less extent the tendency to being sticky than the sun-dried cloth, while it was at the same time equally water-proof. Only one ounce of the *roghan* was used per square yard, but it was subsequently found that it was preferable to give that quantity per square foot and to utilize the extra supply in two or possibly three applications.

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WATER-PROOFING CLOTH.

But when turpentine was employed as a solvent (equal quantities) the *roghan* could be readily applied with a brush and perhaps less than one-third the quantity of *roghan* was then necessary to cover the fabric. But in neither of these experiments did the painted cloth dry as quickly nor as effectually as was necessary for commercial purposes.

Experiments were accordingly next performed with various pigments added to the *roghan* to facilitate the drying. All the ordinary substances of that class were experimented with such as white lead, red-lead, yellow arsenic and manganese dioxide. The best results were obtained when the mixed *roghan* and pigment were dissolved in turpentine and applied with a brush. The hot *roghan* and pigment was exceedingly difficult of application with the crude appliances at our disposal The expense of turpentine rendered it desirable to ascertain whether that solvent could be dispensed with. In every instance the manganese dioxide gave the best result The fabrics produced were perfectly water-proof, but the drying was slow and never quite satisfactory.

Expert's report.

This somewhat disappointing result led me to seek the assistance of a professional manufacturer of water-proof sheetings. Messrs. Octavius Steel & Co., were accordingly approached, and they were good enough to permit their expert, Mr. Jos. Patrick, to visit the Museum and to inspect our laboratory experiments. Mr. Patrick examined the *polli* and *roghan* and professed himself much interested. He was accordingly supplied with a sufficient quantity of both to allow of his performing experiments with them. The result, as was to be expected, in respect to the oil proved most instructive. Mr. Patrick made the interesting discovery that for water-proofing purposes the *roghan* as procured from Peshawar had been boiled much too long In other words, that the drying property of the *polli* oil boiled for 4 hours is greater than when boiled for 12 hours—the time given by the Peshawar wax-cloth workers. Mr Patrick's six samples of cloth prepared by him were treated as follows:—

No 1 Roghan, Litharge and Turpentine.
No. 2 Roghan, Red-lead and Turpentine.
No 3 Roghan, White-lead and Turpentine.
No. 4=No 1 with black colour added.
No. 5=No 2 with Ochre added.
No 6=No. 3 with White-lead for colouring.

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PLATE NO. 2.

Modern adaptation used in decoration of

curtains, table cloths, etc.

All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

This sheet and the title-page may be removed when the subject-matter is filed in its proper place according to the letter and number shown at the bottom of each page.

THE

AGRICULTURAL LEDGER.

1901—No. 13.

REH.

[*DICTIONARY OF ECONOMIC PRODUCTS, Vol. VI., Pt. I., R. 67-70.*]

An account of the attempts which have been made to utilize the upland barren lands (usar) of the North-Western Provinces and Oudh for profitable purposes. By W. H. MORELAND, ESQ, *Director, Department of Land Records and Agriculture, North-Western Provinces and Oudh.*

Other PAPERS that may be consulted:

Agricultural Ledger, 1893, Nos. 12 and 13; 1896, No. 1; 1897, Nos. 7 and 13; 1901, No. 4.



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AGENTS.

In Britain.

E. A. Arnold, Esq, 37, Bedford Street, Strand, W.C.

Messrs

Constable & Co., 2, Whitehall Gardens, London, S. W.

Sampson Low, Marston & Co, St. Dunstan's House, Fetter Lane, London, E C.

P. S. King & Son, 2 & 4, Great Smith Street, London, Westminster, S.W.

Messrs

Luzac & Co., 46, Great Russel Street, W. C.

Kegan Paul Trench, Trübner & Co., Charing Cross Road, London, W. C.

B. Alfred Quaritch, Esq., 15, Piccadilly, London, E.

Williams and Norgate, Oxford.

Deighton Bell & Co, Cambridge.

On the Continent.

Messrs

R. Friedländer & Sohn, Carlstrasse, 11, Berlin, N.W.

Otto Harrassowitz, Leipzig.

Karl W. Hiersemann, Esq, Leipzig.

Ernest Leroux, Esq., 28, Rue Bonaparte, Paris.

Martinus Nijhoff, Esq, The Hague.

In India.

Messrs.

Thacker, Spink & Co., Calcutta and Simla.

Newman & Co., Calcutta.

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Superintendent, American Baptist Mission Press, Rangoon.

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A. J. Combridge & Co, Bombay

TWO KINDS OF BARREN LAND

the three million acres included in the third class. All of this land is not rendered barren by the same defects, but there are no accurate statistics of the area which suffers from each cause. Leaving out all minor subdivisions, the barren land may be classed as due either to the effects of erosion or to the want of drainage, the latter cause accounting for considerably the greater proportion of the area.

Cause of barrenness

First kind—ravined

Land which has been rendered barren by erosion can usually be identified at a glance: the surface is broken by water channels, and *there is an entire absence of soil in the strict sense of the word; the* soil has in fact been washed away, and the surface of the land is composed of clay sufficiently tenacious to resist for a time the action of running water. In some cases however the nature of the defect is not so apparent, and the barren tract would at first sight be classed as *usar* in the current use of that term. This occurs where the land through which a stream passes has originally had a more or less regular subsoil of hard clay, as the stream gradually wears a bed through this, everything on the surface is washed down and the clay subsoil exposed. The resistance of the clay prevents the stream from cutting a deep bed, and consequently the process of ravining can take place, if at all, only on a very small scale; but any attempt at cultivation in the ordinary way is doomed to failure, as the tilth is washed away as soon as produced.

Some forms might pass for usar on casual inspection.

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(Mineral and Metallic Series, No. 18.)

THE AGRICULTURAL LEDGER.

1901—No. 13.

REH.

[*Dictionary of Economic Products, Vol. VI., Pt I., R 67-70*]

An account of the attempts which have been made to utilize the upland barren lands (usar) of the North-Western Provinces and Oudh for profitable purposes. By W. H MORELAND, ESQ, *Director, Department of Land Records and Agriculture, North-Western Provinces and Oudh.*

PREFACE.

The draft of this note was circulated to a large number of officers for criticism, and I desire to express my obligations to all those who have been kind enough to assist me.

The botanical nomenclature follows that of the Flora of British India, so that many plants appear under names differing from those which were used in the older reports In such cases the synonyms have been given in foot-notes.

CHAPTER I.

Introductory.

AREA OF BARREN LAND IN N.-W. PROVINCES AND OUDH

The area of barren land in these Provinces is returned at 8,880,959 acres, which is classified as follows:—

	Acres.
Land covered with water	2,847,685
Land occupied by houses, roads, etc. . .	2,884,255
Land barren for other reasons . . .	3,149,019

The two former classes are not available for agricultural purposes, and the problem which has been the subject of special study by the Agricultural Department for the last twenty years is the utilization of

TWO KINDS OF BARREN LAND

Cause of barrenness

the three million acres included in the third class. All of this land is not rendered barren by the same defects, but there are no accurate statistics of the area which suffers from each cause. Leaving out all minor subdivisions, the barren land may be classed as due either to the effects of erosion or to the want of drainage, the latter cause accounting for considerably the greater proportion of the area.

First kind—ravined

Land which has been rendered barren by erosion can usually be identified at a glance: the surface is broken by water channels, and there is an entire absence of soil in the strict sense of the word; the soil has in fact been washed away, and the surface of the land is composed of clay sufficiently tenacious to resist for a time the action of running water. In some cases however the nature of the defect is not so apparent, and the barren tract would at first sight be classed as *usar* in the current use of that term. This occurs where the land through which a stream passes has originally had a more or less regular subsoil of hard clay; as the stream gradually wears a bed through this, everything on the surface is washed down and the clay subsoil exposed. The resistance of the clay prevents the stream from cutting a deep bed, and consequently the process of ravining can take place, if at all, only on a very small scale; but any attempt at cultivation in the ordinary way is doomed to failure, as the tilth is washed away as soon as produced.

Some forms might pass for usar on casual inspection.

Experiments on the utilization of ravine lands have ceased for some years as far as this Department is concerned. The results attained are discussed in *Chapter V* of Dr. Voelcker's *Report on the Improvement of Indian Agriculture,* and need no further reference in this note. The subject has been mentioned only in order to point out that some land which would ordinarily be classed as *usar* must be regarded as ravined, and utilized by the methods which have proved successful in such land, and not by those which are recommended further on for the treatment of *usar* in the strict sense. Lands of this class can be recognized with a little care: if a piece of barren land is seen where the marginal fields are somewhat above the level of the barren land and where the land slopes down to a well-defined water channel, the even surface being usually broken by low, abrupt mounds of hard clay or nodular limestone, then that piece of barren land may be attributed to the action of erosion, and may be treated by one of the methods recommended for utilizing ravined land.

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The second class—land rendered barren by want of drainage or by excessive flow from above—may be further subdivided into (1) the lowlands along rivers and (2) the uplands. The main characteristic of the first subdivision is wetness through a large part of the year; the land being little, if at all, above the level of the river can never be thoroughly drained; and it receives additional supplies of moisture from the soakage of the higher ground. TWO KINDS OF BARREN LAND Second kind—by want of drainage. Its two subdivisions—lowlands and uplands.

The fertility or barrenness of these lowlands is largely a question of season. After a year or two of scanty rainfall much of the land will be found bearing luxuriant crops or at least abundant grass, while after a series of wet years (such as occurred from 1892 to 1894) the land will be unproductive and parts of it will be thickly crusted with the deposit of soda salts popularly known as "*reh*." The probable origin of this deposit will be explained further on; but here it is sufficient to say that the reclamation of such land can be effected, if at all, only by the engineer. The example of the Kali Nadi works in the Bulandshahr district shows that where it is possible to re-align the river channel so as to secure a more rapid flow of water the amount of infertile land can be greatly reduced; but such action is possible only in comparatively few cases, where the river-bed has become obstructed or tortuous and where the river itself is of moderate size. Where these conditions do not exist agricultural science can suggest no practical remedy. All that can be done is to maintain a careful watch over the tracts likely to be so affected, and to adjust the revenue demand to circumstances. If the demand imposed in years of prosperity is collected in bad times, the owners and cultivators become impoverished and are unable to resume cultivation when the seasons change: if the demand is varied in accordance with the productivity of the land, the recovery is often rapid and the land may afford a valuable resource in times of drought when the uplands are too dry for cultivation. The need for watchfulness in such cases is well known to experienced revenue officers, and the organization for securing early information of injury has recently been perfected. LOWLANDS WANTING DRAINAGE. Fertility of lowlands varies much with season. Re-alignment of rivers may in some cases improve them. When this is impossible it remains to adjust the revenue to season.

Similar in nature to the lowlands are those tracts which have been swamped by excessive supply of canal water. Where the level of a canal is high and the subsoil retentive, or there is an impervious stratum of soil near the surface of the ground and running under the canal, the land in the immediate vicinity tends to become swampy; and even where swamps do not actually form the rapid evaporation Conditions leading to swamping with canal water.

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LOWLANDS WANTING DRAINAGE.

from the surface, and the constant upward movement of water from the excessive supply so near the surface, tend to bring up all the soluble salts and accumulate them at the surface, thus giving rise to the formation known as *reh*. The danger of over-saturation is fully recognized by the officers of the Irrigation Department, and most of the affected tracts have been relieved by drainage works, which are known to be an effectual remedy. The remainder of this note refers not to the river valleys nor to the over-saturated areas, but to the land which is rendered barren by other causes.

Adjustment by drainage.

UPLAND BARREN LANDS.

Distribution of upland barren lands

It may be estimated that the upland barren lands extend to about two million acres; they are to be found mainly in the country between the Jumna and the Ganges and between the Ganges and the Gogra. Two particular tracts may be defined in which the barren area forms an exceptionally large proportion of the total. The first of these extends from Aligarh to Allahabad, including the districts of Aligarh, Etah, Mainpuri, Farrukhabad, Etáwah, Cawnpore, Fatehpur, and Allahabad, the proportion reaching a maximum in Mainpuri. The second tract extends from Hardoi to Azamgarh, and includes the districts of Hardoi, Lucknow, Unao, Sultanpur, Partabgarh, Azamgarh, and the north of Jaunpur.

FIRST FORM OF UPLAND BARREN LAND—*USAR*.

The barren land in these tracts is not continuous; it occurs in patches, varying in size from a few square yards to a square mile or more, and its distribution is most irregular. To the eye it presents one or other of two typical forms, which however are not opposed but are the extremes of a continuous series. The first form is usually spoken of as *usar*,* and shows in dry weather an extremely hard compact surface of a colour varying from light to dark grey: here and there may be seen a single *babul* or a stunted *nim* tree, but as a rule the vegetation is limited to scanty grass, usually of the "typical *usar* grass" (Sporobolus arabicus, *Boiss.*)†: other grasses of a somewhat better type are occasionally found, though not in sufficient abundance to afford grazing of much value. During the rainy season the land takes a much darker colour, due to the moisture in the surface

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soil: after heavy rain the water stands on the surface, being unable to soak into the soil, while the wet surface layer becomes so slippery that it is difficult to maintain a foothold. During this season the coarse grasses spring up rapidly and are used for grazing; but they die down very quickly in October, or earlier if September is dry, and though the cattle are turned out on the land during the rest of the year, the grazing is of the poorest description.

SECOND FORM OF UPLAND BARREN LAND.

In the second form the land in the dry season is covered, more or less irregularly, with a crust of white salts, which in the worst places may extend to a depth of some inches. Vegetation is similar in kind to that seen on the first form, but is still scantier and is absent where the efflorescence is well defined. During the rains the salts entirely disappear, and the surface of the land is seen to be similar to that of the first form.

The marked external features of the barren lands soon attracted official attention, and various investigations have from time to time been set on foot. It will be convenient to give in this place a brief account of the more important literature on the subject.

CHAPTER II.

The Literature of the Subject.

THE LITERATURE OF BARREN LANDS. Sleeman's description.

The earliest discussion of the barren lands which I have been able to discover is contained in Sleeman's journal of his tour through Oudh, published in 1858, but written eight or nine years earlier. He describes the *usar* plains of South Oudh, offers a theory which in essentials is not very far from being in accordance with the views that now find acceptance, and gives an account of the methods of reclamation that were practised by the people. The next important steps in the investigation of the subject are detailed in the "Correspondence relating to the deterioration of lands from the presence in the soil of *reh*," which was published in 1864 as No. XLII *of the Selections from the Records of the Government of India*. This correspondence deals with the deterioration of certain villages lying along the Western Jumna Canal, and it shows clearly that while the canal was not responsible for the presence of injurious salts in the affected tracts, its construction and the neglect of the necessary drainage works had led to the accumulation of the salts at the surface in such quantities as to render cultivation impossible. The correspondence therefore deals

Correspondence on the result of over-saturation from the Western Jumna canal.

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THE LITERATURE OF BARREN LANDS.

Revenue Settlement of Western Doab resulting in planting experiments in Aligarh and some silting experiments.

directly with the results of canal over-saturation, but indirectly it contains valuable materials for the general study of the formation of alkali.

No record of investigations during the next ten years has come to my notice, but in the early seventies, when the districts of the Central Doab were under settlement, the question naturally came into prominence, and a set of enquiries on the subject was circulated to revenue officers. The replies were issued in 1874 with a note by Mr. (now Sir Edward) Buck, and minutes by the Members of the Board of Revenue. I cannot find that any immediate action was taken as the results of these enquiries beyond the formation of a plantation at Pardil Nagar in Aligarh and some silting experiments which were carried out by the Irrigation Department, but the subject was reopened in 1876 when a planter complained that his lands had been injured by the mismanagement of canal irrigation. A committee was then appointed to examine the whole question, and as the result of their enquiries a scheme of experimental work was drawn up to be carried out mainly by the newly-formed Agricultural Department, and to include arboriculture, surface and subsoil drainage, flushing, manuring, and the growth of special crops. The discussions of this committee led to no conclusion on questions of theory; but it is worthy of note that the theory of alkali stated by Mr H. B. Medlicott, then *Superintendent of the Geological Survey* and one of the members of the committee, is that which now commands universal acceptance.

During deliberations of Committee of 1876 Medlicott put forward the accepted theory of alkali.

The deliberations led also to the carrying out of experiments to be described.

The scheme prepared by the committee was carried out with some occasional breaches of continuity and is now completed. The work done and the results obtained will be detailed further on; but it may be pointed out in this place that the value of the work would have been greatly increased if analyses had been made of the soil of the plots on which the experiments were made; if such analyses were made there is now no record of them, and it is thus sometimes difficult to form an accurate opinion of the results, or to apply them to other land intended to be reclaimed. This defect was pointed out in paragraph 78 of Dr. Voelcker's *Report on Indian Agriculture*, and as one result of his enquiries, an Agricultural Chemist (Dr. J. W. Leather) was brought on the staff of the Imperial Department and his services made available for these investigations.

Dr. Leather's chemical investigations follow

Some results of Dr Leather's chemical investigations have been published in *The Agricultural Ledger* (Nos. 12 and 13 of 1893 and Nos. 7 and 13 of 1897); but no detailed account of the agricultural

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work of the last twenty years has been prepared, the subject being noticed at greater or less length in the annual reports of this Department. The details given in these reports and such other information as was on record have now been brought together; but they may conveniently be prefaced by a brief account of what is known regarding the accumulation of alkali at the surface of the soil. As already indicated, the main theory was clearly stated by Mr. Medlicott; the earliest suggestions for the chemical treatment of alkali were made by Dr. Brown and by Dr. Romanis, the Chemical Examiner of Burma, while [illegible]
of org. [illegible]
Economic Products. Subsequently the limited number of scientific men in the country appear to have turned their energies in other directions, and the later investigations on the subject have for the most part being the work of Professor E. W. Hilgard and his colleagues on the staff of the *California experiment station*; it is unnecessary for my present purpose to give references to the original papers, as the subject is clearly explained in the last chapter of Professor Warington's "*Lectures on some of the Physical Properties of Soils*" (*Clarendon Press, 1900*), and in a summary of the work in California printed as *Bulletin No. 128 of the Californian experimental station*, for copies of which I am indebted to Professor Hilgard. Some of Professor Hilgard's papers have been reviewed in *The Agricultural Ledger* (see No. 1 of 1896 and No. 4 of 1901).

THE LITERATURE OF BARREN LANDS.

Various scientific [illegible]

CHAPTER III.

The Accumulation and Movements of Salts in the Soil and their Effects on Vegetation.

The results of scientific investigation may be shortly summarized as follows. Practically all soils contain the materials which go to form the salts known collectively as *reh* or alkali. The principal base of these salts is soda, which is combined with chlorine or with sulphuric or carbonic acid, forming sodium chloride (common salt), sodium sulphate, or sodium carbonate. A certain amount of some of these salts is to be found in the soil at any given moment, but this amount does not by any means represent the total of salts which can be produced. Most soils contain a considerable proportion of complex silicates, of which soda is a usual ingredient. These

SALINITY OF SOILS.

Chief salts in soils.

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SALINITY OF SOILS.

Tolerance of plants has been thus tested in India.

Dr. Leather's results in this country are given in *Agricultural Ledger No. 13 of 1897*. In pot experiments he found that germination of ordinary crops was possible at least up to 0·4 per cent. of carbonate and to 1·0 per cent of sulphate and chloride In aftergrowth 0·2 of carbonate was harmful, while 0·4 was generally fatal. The results with chloride were not uniform, sulphate was less harmful than either carbonate or chloride. The Leguminous plants gram, (Cicer arietinum, *Linn.*) peas, and *arhar*, (Cajanus indicus, *Spreng.*) suffered most. Of the cereals, maize was least affected—a result which may possibly be attributed to the difference of season. Analysis of samples taken from cultivated fields showed that wheat grew well in the presence of 0·137 of carbonate, but was destroyed by 0·2 per cent.

Different salts differ in degree of harmfulness.

On the whole the following conclusions may be drawn:—

(*a*) Carbonate is most harmful and sulphate least harmful.
(*b*) Legumes are more affected than cereals.
(*c*) A proportion of 0·2 per cent of carbonate in the soil around the roots is fatal to cereals.

The reasons why carbonate is more injurious than the other salts are stated to be (1) its greater corrosive effect on the bark of the plant and (2) its action in "puddling" the soil and rendering it difficult of tillage

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CHAPTER IV.

The Nature of the Usar Soils in these Provinces.

NATURE OF USAR SOILS.

Classification best by percentage of salt present.

Classification—Before applying the results of the investigations described in the last chapter to the barren lands of these Provinces, it will be well to give a somewhat fuller description of their physical and chemical characteristics to supplement what has already been said regarding their general appearance. The barren uplands have, it will be remembered, been divided into two classes, according to the presence or absence of alkali efflorescence; but this classification is made for descriptive purposes only. Efflorescence depends on the quantity of salts at the surface of the soil, and this quantity differs from plot to plot, so that the barren lands should rather be regarded as arranged in a series according to the amount of soda salts which they contain, an amount which on the one hand may reach or exceed 3 per cent. in the first six inches of soil, or which on the other hand may not be more than is consistent with thriving vegetation. A more practical preliminary classification would there-

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fore depend on the total amount of salts within reach of the surface (the method followed by Hilgard *in California*). The first class would then consist of soils where the total amount of salts is not excessive and consequently reclamation can be effected by altering the distribution of the salts, or in popular phrase "keeping the salts down". The second class would include those soils where the amount of salts is so great that the removal of some portion, or their conversion to a less noxious form, is a necessary preliminary.

THE NATURE OF USAR SOILS

Physical character.—In all cases the barren lands are found to have one leading characteristic—the impermeability of the soil for a varying depth below the first few inches. Examination of the subsoil by means of pits shows that the upper layer consists of extremely fine clay (using this term in the popular and not the chemical sense), with practically no fissures except where ants or worms have established themselves: animal life however is not found where the surface is very alkaline. The depth of this layer of clay varies from as little as half a metre to three metres (in cases where the pit has been sunk so deep): below the layer of clay is usually found a coarser material, often of a yellowish colour. The clay is for all practical purposes impermeable by water, while the coarser layer is more or less porous. The form of impure calcium carbonate known as "*kankar*" (nodular limestone) is generally, but not universally, found in the layer of clay at varying depths and in varying amount: sometimes these are merely small scattered nodules, while in other places the formation is so thick and continuous as to practically form a rock, it is from the latter formation that is derived the "block *kankar*" which is used for pitching bridge piers and embankments. The depth to which *kankar* may be formed is not known. The professional *kankar*-diggers do not as a rule look for it below four feet,—the length of the *seel* or iron sounding rod which they use. I have found it with a similar rod as deep as two metres, while exposed sections on river banks in some cases show successive layers of the same formation; and records of deep borings show that *kankar* reefs are met with at intervals throughout the alluvium.

Physical characters, chief one impermeability.

Depth of soil.

Presence of Kankar.

The impermeability of a hard *usar* may be illustrated by the following note of observations made at the Juhi reserve. A plot of land was covered by a thatch in June 1900, and surface flow on to it was prevented by a border of sheet iron sunk two inches deep. This plot remained covered till August 30th, 1901. During August there had

An illustration of the impermeability of usar soil.

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THE FEATURES OBSERVED IN USAR SOILS.

been very heavy rain and the whole surface of the *usar* was waterlogged. Inside the enclosure the ground was hard and dry and almost impossible to dig: down to about 10 inches there was no trace of moisture at a foot from the edge of the enclosure. Outside the enclosure the ground was soaked to 11 or 12 inches: below that it was dry and crumbly, or in six weeks of heavy rain percolation had reached downward only to the bottom of the grass roots.

The following notes of a continuous series of observations on barren land made between November 1899 and January 1900 during a tour in Cawnpore, Fatehpur, and Allahabad may serve to illustrate the foregoing remarks as to the physical conditions which are found in such cases. Fairly complete records were made of 54 trial pits which were sunk one metre or more, except where a hard reef of *kankar* was found at a lesser depth; of these, 26 pits were roughly classed as being in soil obviously alkali and 28 in other soils, the presence of alkali being determined roughly by the eye and the taste.

Want of vegetation

Of the 26 pits in alkali land, the surface was bare of all vegetation in eighteen cases, while in eight there were scanty tufts of withered *usar* grass. In no case was vegetation copious.

Want of animal life

Traces of insect life (ants, worms, white-ants, etc.) were entirely absent in fifteen cases and were very scanty in eight. The facts were not noted in three cases. In no case was insect life copious.

Clay.

In all cases the subsoil was a very compact clay; in only four cases was it fairly dry; while in nineteen cases it was distinctly moist, though no rain fell during the tour, and the surface soil was in every case dry.

Karkar

In nineteen cases the presence of a *kankar* stratum was sought up to two metres, the ordinary sounding rod being used when a reef was not found in the pit. In thirteen cases a reef was found in the first metre, in five cases in the second metre, and only in one case was no reef found.

Nodules of limestone

Scattered nodules of limestone, known locally as "*bajri*," were found in the clay of the first metre in the majority of cases, but were by no means always present.

Want of drainage.

The drainage facilities were tested in thirteen cases where water was available. In eleven cases no percolation whatever could be detected, while in the other two the clay was very slightly pervious. In both these cases the pits were close to a high level canal, and the water level in the soil was high, the water in adjacent wells standing

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THE FEATURES OBSERVED IN USAR SOILS.

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Upland Barren Lands (Usar). (*W. H. Moreland.*) | REH.

RESULT OF ANALYSIS OF USAR SOILS.

Analyses of Usar Soils—contd.

	Soil.	Percentage of				
		Carbonate.	Sulphate.	Chloride.	Total soda salts.	Remarks.
Alkaline soil at Barauli in Farrukhabad.	Bare efflorescent— First 6 inches .	·087	1·313	Not given	...	
	7 to 30 „ .	·159	1·388	do.	...	
	Grass land covered with alkali— First 6 inches .	·140	1·186	do.	...	
	7 to 30 „ .	022	·191	do.	...	

CLIMATIC CONDITIONS TENDING TO FORMATION OF USAR LANDS.

Origin.—Such being the general features of the barren lands, the theory already stated may be applied to them as follows:—

In the first place the climate is obviously adapted to secure the maximum surface accumulation of salts. The heavy rainfall is confined to about three months, and on level land most of it either soaks into the ground or lies on the surface. During the end of September and the whole of October the heat of the sun is very great, and during the rest of the cold weather the heat is at any rate sufficient to maintain a brisk rate of evaporation. Observations of the soil temperature are wanting, but the rate of evaporation is a fact that cannot be disputed.

In this climate then the only chance of washing out the salts as formed is that the soil should be porous; but any one can satisfy himself by a few simple experiments that there is in real *usar* no percolation whatever in the ordinary sense of the term. The water lies on the surface and gradually soaks down to an extent that depends on the nature of the season or here and there finds crevices into which it can percolate, but it practically never gets so far as to escape into the drainage system of the country. Thus so much of the rainfall as has been absorbed is retained comparatively near the surface, and is ready to be evaporated as soon as the rains come to an end.

Again, when the season of evaporation begins, everything tends to its acceleration. The vegetation is either scanty or soon dies down, or if it is in any quantity is grazed by the cattle, and the

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CONDITIONS TENDING TO LOCALISE THE FORMATION OF USAR LANDS.

surface is left bare to the action of the sun. Again, the texture of the soil is specially adapted to further evaporation. Thus the existing *usar* soils are in every way fitted to secure a maximum accumulation of salts at the surface.*

The irregularity of the surface distribution of the alkali has always attracted attention. It may perhaps be explained as in the main the result of two causes—(*a*) difference in the original alluvial deposits, and (*b*) the annually recurring struggle of the vegetation. It is of course impossible to ascertain the conditions under which any particular tract of barren land was formed during the original deposition of the gangetic alluvium; but it may be conjectured that at an earlier period, before the depression of the deltaic region (*vide page 434, "Manual of the Geology of India, 1893"*), the main rivers did not flow in their present deep valleys, but the water had much freer scope to travel over the surface of the plain. Small accidental surface irregularities would then have an important effect in determining the flow and the deposit of silt. If, for instance, pools or backwaters formed where the water, having already deposited the coarser particles of its burthen, became more or less stagnant and yielded up only the finest silt which remained, the conditions would be present for the deposit of the very compact "clays" which form the bulk of the barren lands. The quantity of soda salts in these would depend on the proportion of silicates containing soda, which again would vary according to the origin of the silt, the relative influence of different tributary streams varying at different seasons or in different years. If again these pools or backwaters dried up in the seasons of least flow, whatever soda salts they carried in solution would be added to the soil, and being highly soluble would be carried into it at the next wetting and not washed off the surface.

It seems probable that the clays were formed in something like this manner, and that their composition would vary greatly according

* It is important to bear in mind the distinction between percolation and capillary motion. Water percolates downwards when the particles of soil are not closely packed but leave free passages; when the particles are closely packed percolation is retarded or prevented. Capillary motion of water on the other hand takes place upwards or downwards so as to

wet as the upper; that is to say the upper soil cannot be drained.

RECLAMATION OF USAR LANDS.

when the soil has thus been raised to the first class the treatment indicated above may be applied.

Methods at our disposal for the purpose.

Agricultural science indicates various methods of improving defective texture: the *principal are subsoil drainage, deep tillage* addition of bulky organic matter (either manures or green crops ploughed in), soil-mixing, liming, and burning. From the account to be given in the next chapter it will be seen that deep tillage, combined with the addition of bulky organic matter, has given satisfactory results; that subsoil drainage has been condemned as unsuitable, though not to my mind on sufficient grounds; and that soil-mixing, liming, and burning have not been fully tried. Burning is not ordinarily a desirable method of reclamation, though I intend to give it a trial; and cost of carriage will usually prevent mixing on a large scale; but liming seems practicable, and it is a little strange that it has not been tried more extensively. Experiments in this direction have lately been started.

CHAPTER V.

Cultivation of Usar.

INDIGENOUS METHODS OF ATTEMPTING RECLAMATION.

Indigenous methods.—Reclamation of *usar* lands is not unknown to the cultivators in places where the pressure on the soil is great. Sleeman has recorded the opinion on this subject which prevailed in South Oudh fifty years ago. When passing from Partábgarh to Rae Bareli he writes :—

"The people say......that *usar* to be reclaimed has to be flooded [illegible] manu- [illegible] toler- [illegible] *age 224* (*1858 edition*).

Flooding and cultivating.

And when passing through Unao he wrote: "Some people said the worst of the *usar* could be cultivated; others denied it. All agreed that any but the worst could be reclaimed by flooding for two or three years, cross-ploughing, manuring, and irrigating. All the soil is liable to become *usar* if neglected or left fallow for a few years Certainly *usar* prevails near the high roads where the peasantry are exposed to the rapacity of the king's troops; and this tends to confirm the notion that tillage is necessary in certain soils to check the tendency of salts to superabundance." *Sleeman's "Tour through Oudh," Volume I, page 277.*

A description of an indigenous method of reclamation is to be

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found in paragraph 18 of Mr. J. R. Reid's *Settlement report on Azamgarh*—a district where the pressure on the soil is notoriously excessive. The method consists in retaining the rain water by embankments and growing rice while the land is under water; it is applicable only to the better kinds of *usar*, and its application is limited by the scarcity of water. Mr. D. C. Baillie, C.S., informs me that he has seen most successful reclamation in this way in Partábgarh district; he notes that it is essential that the part of the *usar* embanked be so placed as to receive the surplus rainfall from higher levels. The rainfall on the land itself is not sufficient. INDIGENOUS METHODS OF ATTEMPTING RECLAMATION.

In Budaun small patches of *usar* are improved by ploughing into them the worn-out thatch of the houses, and the practice is said to be efficacious. Ploughing in thatch.

The reclamation of barren land formed the subject of the fifth question of those issued by the *Board of Revenue in 1873-74*, and from the printed collection of replies it appears that instances of reclamation were known in many districts, but that reclamation on a large scale had not been attempted. On the whole it is clear that the improvement effected by native methods has been limited to small patches of the better kinds of *usar*, and that reclamation on a large scale has not appeared sufficiently attractive as an investment to landowners who could command the necessary capital. Reclamation on a large scale never attempted.

An important section of the experiments carried out under the *Reh* Committee's scheme was directed towards preparing the soil for profitable cultivation by (1) removal of salts, (2) drainage, (3) silting, (4) deep cultivation, manuring, and ploughing in green crops. RECLAMATION EXPERIMENTS MADE UNDER GOVERNMENT.

Removal of salts.—This was tried in the Awa estate. The salts on the surface were scraped off before the rainy season, and in the following year the quantity of salts was found to be decidedly less; but the subsequent history of this plot cannot be ascertained, and it is not known whether it was ever cultivated. As indicated at the close of the last chapter, this treatment, while not likely to result in reclamation unless supplemented by improvement of texture, may turn out to be a valuable preliminary process for *reh* land, and the most economical and effective methods will be determined *Departmental Report for 1880-81, Appendix D.* By removal of salts.

Surface drainage.—Two experiments were conducted at Awa on the effects of surface drainage. In one plot the land was thrown into ridges and furrows, the furrows being 10 feet apart and the ridges By surface drainage.

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one foot in height at the top of the slope. In the second plot surface drains were dug six feet apart. *Departmental Report for 1880-81, Appendix D.*

Mr. Wilson wrote in 1881:—

"It was hoped that the rain would wash the salt out of the ridges into the furrows and channels. There certainly appears to be more *reh* in the furrows than in the ridges, but the latter are not yet clean enough for cultivation. Indigo and peas were sown on the ridges during the rains: a few seeds germinated, but the plants died before they were six inches high. The ridges were then manured: wheat and barley were sown, but the few plants that appeared very soon died."

Failure of surface drainage.

These plots are again referred to in the report for 1881-82: the ridges were sown in both harvests, but most of the seeds failed to germinate, and the few plants that came up dried when they were only a few inches high. No further reference can be found to this experiment, which was apparently abandoned. The failure to wash the salts out of the ridges may be attributed to two conditions which are to be found in all *usar*—the extreme solubility of the salts, and the impermeability of the soil. Owing to the first condition the salts are dissolved by the first few drops of rain that fall on them, so that most of the salts have already been carried into the surface soil by the time it is moistened, that is before the surface flow of water can begin. That this is the case may be verified by watching the effects of a shower on an alkali patch or by sprinkling it from a watering-can. Once the salts have been carried into the soil, the impermeability prevents any large proportion of them being washed into the drains or furrows These considerations appear to me to be fatal to the success of any system of surface drainage. *Departmental Report for 1881-82, Appendix II, paragraph 17.*

Subsoil drainage.

Subsoil drainage.—Experiments with subsoil drainage were made at the same time. *Departmental Report for 1881-82, Appendix II, paragraph 19.* Two inch pipes with collars were laid 20 feet apart 2 feet 6 inches to 3 feet deep, and with a slope of 6 inches in 100 feet. In the first season the drains silted up during the rains and the land showed no improvement. The pipes were relaid and the plot flooded with canal water whenever it was available. *Departmental Report for 1882-83, Appendix I, paragraph 12.* The surface was dug to a depth of one foot and a portion of it was limed. Mr. Wilson wrote in 1883:—

"There are signs of the soil having been cleansed to some extent, but it is not yet fit for growing ordinary crops. The extreme

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Improvement due to subsoil drainage.

In the third year the plot was sown partly with rice and partly with hemp, but both crops failed entirely. In the *rabi* season wheat and barley were sown, and though the seed did not germinate at all uniformly, a decided improvement was apparent in parts of the plot, and some of the plants of wheat matured. *Departmental Report for 1883-84, Appendix I, paragraph 15.* Mr. Wilson wrote: "The soil still contains an excess of saline matter, and from a pecuniary point of view the experiment is a failure." It was not apparently continued.

Objections to subsoil drainage.

American experience regards subsoil drainage as an absolute cure for alkali, but the method is considered objectionable, as the drainage which removes the alkali removes also a portion of the other soluble salts which are required for plant food, and it is regarded as a last resort when more moderate treatment has failed or is certain to fail. The method is in accordance with agricultural theory, and I do not think it should be condemned on a single experiment lasting only for three years, specially as its effect should be determined in combination with other methods of improving texture. I am therefore repeating the experiment on a small scale and on modified lines at the Gursikran station. In this experiment the drains have worked well during the first season: rough analyses of samples of the drainage water showed that they contained quantities of soluble salt (almost entirely carbonate of soda) varying from 1 gramme to 4 grammes per litre. It will however be premature to draw any conclusions for some time.

Repetition of experiment.

Silting.

Silting.—Thus it will be seen that the attempts to remove the injurious salts, either directly or by means of water, have so far been a failure. The treatment described as *silting* is a form of soil-mixing which aims, not at removing the salts, but at burying the infected soil beneath an accumulation of silt. This treatment was tried at Awa and also at other places, the latter experiments being placed under the supervision of irrigation officers.

Mr. Wilson describes the Awa experiment as follows:—

"A plot of land was dug to a depth of three feet and all the *kankar* in it was removed. It was flooded with canal water every week when the distributary near it was running. Some hemp, which was sown in a field of good land in the neighbourhood, was

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ploughed into part of the plot. A mixture of wheat, barley, and peas was sown in half of it and mangold-wurzel in the rest, but no crop was obtained. After irrigation the plot was covered with saline efflorescence." *Departmental Report for 1881-82, Appendix II, paragraph 20.*

A short incomplete and unsuccessful experiment in silting

It will be seen that this was not merely a silting experiment, as deep tillage and ploughing in were also practised. The further history of the plot is not traceable, but the latter experiments show that the process of silting requires more than one year. The whole history of the silting experiments undertaken by the Irrigation Department is not on record in my library, but the following facts show the results of the system.

Other more successful experiments.

Three plots in the Etáwah district were treated by flushing and deposition of silt, and in 1889 Mr. Holderness wrote of them: "Two of the plots may now be considered to have been fairly well reclaimed, the larger of the two having been let at a low rent for five years to a good tenant, and the third, which has been only two years under treatment, is progressing favourably." *Departmental Report for 1888-89, paragraph 5.*

A fuller account of the same plots is given in the report for the following year. *Departmental Report (for 1889-90, Appendix C.* About 40 acres of land in Takran was enclosed in 1874 and flooded until a layer of silt, varying from three feet to four inches, had been deposited. In subsequent years occasional flooding appears to have been practised. In 1875 the land was let for R25 rising to R33-5-4, inclusive of water rate, and it continued under cultivation. In 1883 an area of 33 acres was fairly productive, the rest lay higher, and consequently there was difficulty in depositing silt on it. In 1889-90 the land was leased for R96, including water rate: deducting this the net rent of the plot was only R18-8-1. The total direct expenditure was R416, but to this should be added the value of the water supplied, which is not known.

The second plot at Kandan bridge was similarly covered with silt; there was some difficulty in letting it, and cultivation carried on departmentally resulted in financial loss.

A third plot at Turaia bridge was taken up in 1889-90 for similar treatment, but no account of its progress is to be traced in my records.

[S]ilting can [h]ave but a [lim]ited application.

Silting to a moderate depth may be regarded as a special form of soil-mixing, and its beneficial results will depend largely on the coarseness of the silt. The drawbacks to this form of mixing are (1)

it can be carried out only where the water-supply is above the level of the land to be reclaimed; (2) it depends on a very plentiful supply of canal water; and (3) the silt must either be of comparatively coarse texture, or it must be deposited in such quantities as practically to form an entirely new soil on top of the *usar*. The method is therefore of very limited application; it can be carried out by the Irrigation Department where the levels are suitable and where there is sufficient water that would otherwise run to waste; and it could be done by landholders if they are allowed to take the surplus water on very favourable terms. RECLAMATION EXPERIMENTS MADE UNDER GOVERNMENT.

Soil-mixing.—Along with these experiments may be noticed the trial of soil-mixing started by one of my predecessors at Juhi. A plot of land was prepared for cultivation in the usual way, and one half of it treated with a dressing of three inches of coarse sand (obtained mostly in sinking a well in the reserve). The land was sown with various crops, and the outturn was distinctly better than that of the control plot, while during growth the improvement caused by the sand was very conspicuous. The method is theoretically sound, but can in practice be profitable only when sand *in sufficient quantities* can be obtained near the *usar* and where carriage can be cheaply effected. It should also be noticed that the Juhi reserve is not much infected with alkali, recent analyses showing that chemically there is no reason why cultivation should not be successful: the defect of this land is in the mechanical texture. Soil-mixing has not yet been tried on real alkali land in these Provinces. Soil mixing. [illegible]

The *optimum* amount of sand is not known: a dressing of one inch depth goes a comparatively little way, but this quantity would require for an acre as much as 3,630 cubic feet, or the load of about 220 ordinary two-bullock carts. (Such a cart will not carry more than about 16 cubic feet.) The expense would thus be prohibitive, except perhaps where carts and bullocks happen to be standing idle; and this method of reclamation is not recommended. [illegible]

Tillage and manure.—The records of experiments with thorough cultivation are more complete than those which I have recently discussed. The Amramau plot in Cawnpore may first be considered: this plot measured 54 acres, and was acquired in 1882. For the first few years not much was done beyond enclosure to prevent grazing, but in 1885 cultivation was seriously started. Some land was broken up each year, while cattle were kept on the untouched area, Tillage and manure.

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the produce being sold and the manure utilized for cultivation. The treatment applied was as follows:—In the first year the land was embanked to retain the rain water, and was ploughed to a depth of five inches. Four ploughings were given between June and December. The land was then rolled, ploughed, and manured with from 15 to 22 tons (400 to 600 maunds) of half-rotted cowdung to the *acre*. In June of the second year the land was ploughed again and sown with a hardy variety of rice. If this succeeded, a further dressing of manure (100 to 150 maunds) was applied in the autumn and barley or peas sown. If the rice failed, the first year's treatment was repeated. In the third year rice was sown again, and uniformly succeeded; it was followed by barley or peas, and these again by ordinary *kharif* crops (maize, *juar*, or *bajra*). After this the land was leased to tenants at about R8 per acre. In 1892, when 39 acres had been successfully reclaimed, the reserve was sold for R2,050 and the balance sheet stood as follows:—

Fertility gained by the method at Amramau.

Capital Account.

Expenditure.	*R*	*a.*	*p.*	Receipts.	*R*	*a.*	*p.*
Price of land and trees	65	12	0	*Sale of live stock*	*2,234*	*10*	*0*
Enclosure	529	0	0	Value of live stock transferred	1,169	0	0
Live stock	2,241	3	0				
Seed	300	13	0				
Buildings	1,098	10	0	Dead stock transferred	55	0	0
Implements	100	15	0				
Gain on capital account	1,172	5	0	Price of land	2,050	0	0
Total	5,508	10	0	Total	5,508	10	0

Revenue Account.

Expenditure.	*R*	*a.*	*p.*	Receipts.	*R*	*a.*	*p.*
Supervision	1,470	0	0	Rent	582	9	0
Labour	2,942	9	0	Farm produce	839	4	0
Feed of stock	1,091	15	0	Milk	1,616	9	0
Maintenance of premises	136	11	0	Wool, skins, wood, etc.	277	0	0
Miscellaneous	106	5	0	Loss on revenue account	2,432	2	0
Total	5,747	8	0	Total	5,747	8	0

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Thus the operations involved a net expenditure of R1,260, against which is to be set the land revenue, which would be about R70 per annum. Bearing in mind the disadvantages incidental to such operations carried on by Government—payment of excessive prices and high wages for inefficient work, excessive cost of supervision, and possible peculation—it seems probable that similar operations on the land could have been conducted by a private landowner at a moderate profit.

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Possibility of carrying method out to a profit.

The subsequent history of this plot is instructive. The *first proprietors* were expert cultivators, and in 1893-94 the condition of *the* land was found to have further improved. Family disputes *however* ensued, and the land was eventually sold under a decree. *It was* purchased by a man who knew nothing of agriculture and rapidly *fell* into neglect: the land was left fallow and the grass closely *grazed*, so that the improvement resulting from cultivation is being *rapidly* lost: the soil is being gradually compacted, and is returning to the condition which favours the rise of salts.

By neglect the old conditions recur.

The method of reclamation adopted in this case was *to improve* the texture of the soil by thorough cultivation and the addition *of* organic manures. The result was a practical, and not far from a financial success; and the same method can be recommended *with* some confidence where similar conditions recur. One very important condition is the manure supply. In Amramau this was *secured* by maintaining sufficient stock on the land, the produce being *easily* disposed of in the neighbouring city markets. It is doubtful whether equally good results could be attained in rural tracts, unless *special* arrangements could be made for marketing the produce of the stock.

Amramau experiment was in a favourable locality.

A second condition is apparently an adequate water supply, *as it is* important that the land should be kept in cultivation during the *rabi* season. Given plenty of water and manure, with plough cattle strong enough to perform the early tillage, it may be taken as *established* that this method of reclamation may be applied to land which *does* not contain more alkali than Amramau; but unfortunately the original condition of the plot is not accurately known. It was taken up *before* the services of an analyst were available; the officer who was in charge of its reclamation is dead; and statements of work-people cannot be relied on after so long an interval. The land is *nowhere* spoken of as particularly bad, and alkali is not largely prevalent in the barren land in the neighbourhood; it must therefore be assumed that the proportion of alkali was not exceptionally high.

Need of water supply.

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Experiment at Cherat.

Similar methods of reclamation were tried at the Cherat reserve in Aligarh. This land was taken up during 1885 and enclosed by a fence. The original intention was to leave the bad land under whatever grass would grow and to plant *babul*, and perhaps other trees, on the better patches. *Departmental Report for 1884-85, paragraphs 28 and 29*. The original condition of the reserve is thus described in one place:—

"Cherat *usar* is situated in a *reh*-infected tract, and under the influence of a raised water level (due in all probability to the canal), and a miserable system of cultivation, *reh* is steadily spreading in the neighbourhood. The Cherat *usar*, when the Department took it over, was thick in many places with a saline deposit."

On the other hand, according to a description drawn up at the time of acquisition, "the greater part of the land is unculturable, almost bare of trees, and covered with *usar* grass. There is very little saline efflorescence on the surface." As at Amramau, no analysis was made of the unreclaimed land, and having regard to the rather conflicting descriptions just quoted, the most that can be said with confidence is that the land was moderately bad, though the discrepancy may possibly be due to the land having been wet at the time of the second observation. After enclosure had continued for five years, and most of the land was yielding a fair supply of coarse grasses, it was decided to attempt the reclamation of part of this reserve by the methods adopted at Amramau. A start was made in 1890 simultaneously with the establishment of a dairy on the reserve, a plentiful supply of manure being thus secured. *Departmental Report for 1889-90, paragraph 9*. The following extract from the Departmental Report for 1891-92 explains the method adopted and the results secured:—

Tillage operations successful

"In 1890 tillage operations were commenced, and nine acres were [illegible]

have been yielding very fair *kharif* and *rabi* crops; and of the balance, *viz.*, 33 acres, broken up only since July last, $29\frac{3}{4}$ acres have been allowed to lie fallow, exposed to the atmospheric action, in order to prepare them for *kharif* cultivation next June; and $3\frac{1}{4}$ acres have been thoroughly ploughed and manured with farm yard manure, at the rate of 50 maunds per acre, and been sown with mixed peas and barley. During the year under report, of 43 acres reclaimed up to June 1892, $21\frac{1}{2}$ acres were let to tenants in the beginning of the current agricultural year on an annual rent of R170, or R8 the acre, and the rest are managed under departmental supervision.

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Upland Barren Lands (Usar). (*W. H. Moreland*) | RRII.

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Crops grow

"The following table shows the distribution of area during the two agricultural seasons, *rabi* and *kharif*, of the past revenue year:—

Rabi.		*Kharif.*	
Crop.	Area in acres.	Crop.	Area in acres.
Wheat	5·50	Rice	15·10
Barley	6·75	Sugarcane . . .	1·06
Peas	1·25	Fallow . . .	5·59
Gram	2·50	Let to tenants .	21·25
Fallow	27·00	...	...
TOTAL .	43·00	TOTAL .	43·00

"Of the spring crops wheat did well, the yield being $8\frac{1}{4}$ maunds* per acre in a plot in which bone dust was used as manure and $5\frac{1}{2}$ maunds elsewhere. The yield of peas was very good; but gram gave a very poor outturn. The sowing of barley was delayed till the beginning of December by accumulation of rain water on the fields, and the outturn was only $4\frac{1}{2}$ maunds per acre; but it is believed that barley would do well if it had a fair trial.

"*The kharif crop.*—Of the five varieties of rice crops, two, *viz.*, *sathi* and *syamjira*, were raised on a soil manured with common farmyard manure, while in the case of the remaining three no manure was applied. On the unmanured soil a variety of very fine rice, named "*Hiranj*," was grown, and it gave the largest yield. The grain of this rice, as well as of others grown on the reclaimed *usar*, is not inferior to that of the same varieties grown elsewhere. *Sathi* comes next with respect to outturn; but the quantity of manure used of the

recom-

"The area allotted to sugarcane was $1\frac{1}{16}$ acres. The local

es, one of which

, and both were

The crops had

soils forms an object, the plantation of sugarcane would not be disadvantageous.† The percentage of sugar in the cane appears

* One maund = $82\frac{2}{7}$ lbs.

† It may be remarked that the presence of any large quantity of these salts in cane juice would make it useless for manufacturing purposes, and the quantity of alkali removed by a cane crop would be comparatively small.

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however to be below the average. It must also be noted that the soil of Aligarh district is not, generally speaking, suitable for *sugarcane.*"

Treatment of bad spots.

The bad spots on this reserve, which resisted the ordinary treatment, were reclaimed as follows :—After enclosure *usar* grass sprang up here and there, then *bat* grass (Diplachne fusca, *Beauv.*) was sown artificially and ousted the *usar* grass, establishing a good stand of vegetation and materially changing the appearance of the surface soil. When this stage had been reached the ordinary tillage operations followed. These results are instructive, but unfortunately the *bat* grass will not establish itself without copious irrigation in the hot season—a fact which restricts the practical use of the method.

Much irrigation needed.

In 1892 the cultivated area was 86 acres, of which 28 acres had been let at R215. Shortly afterwards the whole reserve was leased to Mr. Keventer, who took over the dairy which had been established experimentally a few years before. The dairy proved a success, and eventually Mr. Keventer purchased the whole reserve—land, buildings, and stock—at a price calculated to cover all the expenditure incurred by Government from the beginning of operations. The land brought under cultivation continues to be profitably utilized for the growth of fodder crops, and with liberal applications of dung and liquid manure from the dairy has greatly improved in condition. The financial result was satisfactory; but the figures cannot be given in detail, as they are complicated by the extensive accounts of the dairy. *Departmental Report for 1892-93, paragraph 12.*

Experiment a financial success.

Experiment at Gursikran.

The Gursikran reserve was taken up at the same time as Cherat; it included two classes of land—a stiff clay with very little alkali and a clay highly impregnated with soda salts (see *the analyses in Chapter IV*). The former was cultivated without much difficulty and let to tenants at remunerative rents: all it needed was thorough breaking up. The latter has been reserved for growth of grass and fuel trees, and the results of these experiments will find a place in *Chapters VII and VIII.*

All that a part of the land needed was a thorough breaking up.

Experiment at Juhi.

The Juhi reserve also, which is very slightly infected with alkali, has been used for the most part for experiments in producing fuel and fodder, but some portions have been broken up for cultivation. The land when once broken up can be cultivated without much difficulty.

Use of nightsoil.

Trenching nightsoil.—An experiment of interest to *Municipalities* was carried through in 1886. The Cawnpore Municipality had trenched some barren land with nightsoil, and after most of the

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prevent any loss of the soluble elements of fertility, so that these soils should be exceptionally rich, and if growth can be induced by any means a fair crop should result. Now in our climate we have the power to induce growth on moderate *usar* during the rains. The salts have then become somewhat more evenly distributed through the soil, and with thorough tillage a crop of some sort can be produced. Whatever is produced, be it crop, weeds or grass, can then be ploughed in before maturity, and this course will improve the texture of the surface and hinder the rise of the salts. The second year of the process will give further benefit, and it should then be possible to get some sort of a winter crop, the shade of which will still further affect the evaporation. In this way it is expected that within three years the land will become fit for cultivation by the ordinary native implements.

Crop for green manure will grow in rains.

I have been assured on the authority of an officer formerly in this Department that this system has been demonstrated a triumphant success where rice has been grown and ploughed in until the required improvement has been achieved; but unfortunately no record of these experiments is to be found in my office, and as all the cultivated *usar* in my charge has been otherwise accounted for, it would appear that the experiments were not conducted on the reserves under this Department. I cannot therefore give details of the processes actually followed, but the experiment so suggested is now being tried. During the last year a successful beginning has been made in Partábgarh to bring *usar* under cultivation by these means. A piece of good *usar* was chosen, which was thoroughly broken, in this instance with a steam plough belonging to the estate; *san* hemp (Crotalaria juncea, *Linn.*) was sown early in the rains, and the crop which was moderately good, ploughed in; barley was then sown, and gave a very respectable crop. It is, I believe, intended to repeat the process this year, after which it is hoped that the land will be fit for letting to cultivators. Even after one year's treatment cultivators offer from R4 to R5 per acre for the land.

Rice is reported to serve the purpose.

Experiment at Partabgarh

San hemp, and barley sown.

This process may be provisionally recommended for trial, the tillage being the best that bullocks or labourers can effect, and the crop used being *san* hemp or rice, according to the wetness of the soil The former is preferable where it will grow, as its cost of cultivation is nominal and its results appear good. Experiments to determine the relative value of different crops for ploughing in are at present in progress.

Special manures.—Before leaving the general subject of cultivation, mention may be made of results obtained with special manures. In the early years of the experiments some hopes were based on chemical or artificial manures, but the use of these has been abandoned since it has been realized that the sterility of the soil was due not to defect of any particular plant food but to badness of texture and to the presence of noxious substances. Thus at Awa a complete series of experiments was carried out with artificial manures; but the results were poor, and stable manure or indigo refuse (*i.e.*, bulky manures) were found decidedly more effective than the chemical fertilizers *Departmental Report for 1880-81, paragraph 18, Appendix D.* RECLAMATION EXPERIMENTS MADE UNDER GOVERNMENT. Use of Manures. Artificial manures not suited but tried at Awa.

The use of gypsum (*Calcium sulphate*) stands on a different footing, as it has been proved that the application of this substance changes the sodium carbonate into the much less injurious sulphate, and it is one of the commonest methods of reclamation in America. *Gypsum* was tried about 1885 with a certain amount of success, but not persevered with. A fresh experiment was started at Gursikran in 1896 on the recommendation of the Agricultural Chemist; the results were inconclusive, and the cost of gypsum landed in the *usar* tracts of these Provinces was found to be so great that the treatment cannot be recommended to agriculturists. *Departmental Report for 1886-87, paragraph 13.* Gypsum

In the experiments in question the gypsum was supplied free of royalty by the Forest Department, but freight, carting, and expenses of applying came to R27 per ton when landed at Gursikran, of this sum, at least R20 would have to be paid by the cultivator, who would also have the royalty to pay. Now, if we assume that R60 is the largest amount which on the average can be profitably spent in reclaiming an acre, the maximum application of gypsum is only 3 tons. According to calculations made by Dr. Leather in the course of the experiment, one ton of gypsum of 85 per cent. purity will neutralise 0·52 ton of carbonate; therefore it will not pay to neutralise more than 1·56 tons of carbonate to the acre But the first two feet of soil weigh about 8,000,000 lbs., or nearly 3,600 tons: 1·56 tons is 0·043 per cent. of this. It would therefore be practical to neutralise carbonate only to the extent of 0·043 per cent.; that is, it might pay where the total carbonate present was 0·2 per cent. or under, but the application would be useless where the proportion exceeded this. To make gypsum profitable for general use the cost of carriage must Chemical action beneficial but cost too great.

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be greatly reduced; but as supplies have to be drawn from the hill districts, there is little probability of a substantial reduction, and the use of gypsum must remain financially unprofitable. The use of lime nitrate with the same object as gypsum was suggested many years ago by Brown, who described a simple method of preparing it in large quantities. I cannot, however, find that it was even tried in these provinces, but the experiment will be introduced.

Lime has been tried but result of trial not recorded.

Lime appears to have been tried many years ago, but no account of the results can be traced. Further trials of it are now being made at Juhi, where the amount of alkali is small.

CHAPTER VI.

Industrial Utilization of Usar.

INDUSTRIAL UTILIZATION OF USAR LAND

The account given in the last chapter practically exhausts the work that has been done in the direction of utilizing the barren land for the production of ordinary crops. Three other general methods of utilization require notice—(1) the introduction of manufactures, (2) the production of supplies of fodder, and (3) the growth of trees valuable for fuel or otherwise. These methods will be noticed in this and the two following chapters.

Trade in crude carbonate of soda.

The extraction from alkali land of crude carbonate of soda for industrial purposes is a very common practice; the alkali is scraped off the ground and the salts dissolved out from the soil and recovered by evaporation. The industry is however organised on a very small scale and the products are inferior.

Glass industries exist where usar lands are found.

An attempt was made during the Awa experiments to establish glass manufacture on the lands infected with alkali. As a matter of fact, wherever alkali is abundant glass industries are to be found; but they are mostly very small, and it is only in parts of the Agra division where they can be called important. The principal products are the common glass bracelets which are usually worn, and of which there is a considerable export from some of the stations in the Etáwah district.

Glass making cannot pay owing to competition with remanufacture of old glass.

In 1878 specimens of glass made from alkali were sent to London for analysis, and were reported to be perfect in composition, except for a slight deficiency of lime, which could easily be made good. A bottle factory was started, and good bottles were made; but it was found that they could not compete in price with the wares of the "bottlewala," who, as is well known, is able to buy up empty

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bottles for a nominal price. In fact the supply of empty bottles appears to be ample for the somewhat limited market in these Provinces. *Departmental Report for 1878-79, paragraph 57.*

Bottle-making having proved a commercial failure, the next attempt made was to introduce the manufacture of beads, which are imported in large quantities. After some preliminary experiments, Mr. Wilson visited Venice in 1880 and obtained a complete set of tools. *Departmental Report for 1880-81, paragraph 28.* As the result of his experiments, the following conclusions were arrived at:—

(1) The impurity of the alkali prevents the manufacture of good colourless glass, such as would be suitable for window glass.

(2) With proper skilled supervision glass can be produced of a quality much superior to the ordinary native manufacture, and probably cheaper.

(3) Good beads can be made, but it is doubtful whether they can be made at a cost lower than that of the imported articles. *Departmental Report for 1881-82, paragraph 37.*

No development of bead-making industry followed demonstration of its possibility.

After two years' further experiments the final conclusion arrived at was that any improvement in manufacture must depend on the work being done on a large scale with skilled supervision. The enquiry then closed, and it was left to the commercial classes to take up the manufacture if they saw profit in it. No development of the industry has followed. *Departmental Report for 1883-84, Appendix I.*

Enquiries have recently been made by a leading firm in the English chemical trade regarding the deposits of soda in these Provinces, and early in 1900 a representative of the firm was supplied with all the information that was available and was shown some of the larger alkali plains. It is not yet known whether his enquiries will lead to any results.

Brick-making.

No enquiries appear to have been made as to the suitability of the clay (at least in tracts not strongly infected with alkali) for the manufacture of earthenware. I hope to take up this subject shortly, though it seems doubtful whether an extensive market could be obtained Mr C. G. Palmer, C.I.E., informs me that bricks made from *usari* soil are extraordinarily hard if burnt enough to fuse the salts into a glass which permeates the whole substance of the brick.

In the year 1882 Major Pilcher, *the Assistant Director of the Oudh Agricultural Department*, suggested to the managers of various

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Paper Mills that English caustic soda could be replaced by the use of soda prepared from alkaline earth. The distance and consequent heavy freight prevented the use of the country material in Calcutta and Bombay, but the *Lucknow Paper Mills* adopted the suggestion and have made their own soda for the last twenty years with most satisfactory results. The supply within a reasonable distance of the mills is however limited.

Soda for paper making.

CHAPTER VII.

The Production of Fodder on Usar.

PRODUCTION OF FODDER.

One main object of the enquiry has from the outset been to discover some means of utilizing the barren land for supplementing the insufficient supply of fodder. A leading feature has been the study of the grasses which grow or can be produced on barren land—a study which has all along been in the hands of Mr. J. F. Duthie, F.L.S., *Director of the Botanical Department of Northern India.* From the outset it was found that enclosure was essential for the proper growth of grass. The close grazing which is universal in these Provinces, and which must be expected to continue so long as land is left unenclosed, is fatal to the proper growth or extension of herbage, the young shoots of grass being nipped off and the tender roots destroyed by the hoofs of the animals.

Close grazing is fatal to the full utilisation of usar land.

Grasses on usar land at Awa.

In an appendix to the report for 1881-82, *Departmental Report for 1881-82, Appendix II, paragraph 15*, Mr. Wilson mentioned the following grasses as being found on the *usar* at Awa :—

(*a*) *Khar usara* (Sporobolus arabicus, *Boiss.*), the usual grass which develops greatly as an immediate result of enclosure.

(*b*) *Bhurburui* (Sporobolus coromandelianus, *Link*), which comes up in the rains but dies away quickly and gives little fodder.

(*c*) *Dab* (Eragrostis cynosuroides, *Beauv.*), which appears on rather better patches, and is of some use for thatching but of little value for fodder.

(*d*) The well-known *dúb* (Cynodon Dactylon, *Pers.*), which is found in depressions where the water lodges, and spreads when the land is flooded with canal water.

Observation of the plots under operations at Awa showed that the result of enclosure was that land previously bare became covered

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with a crop of Sporobolus arabicus, and [illegible] showed a tendency to spread when protected from [illegible] 1881 and 1882 cuttings from selected patches yielded [illegible] one-and-a-half ton of hay per acre; but a note on [illegible] shows that this did not represent the average [illegible] there were at that time numerous bare spaces, [illegible] included in the plots from which cuttings were made.

As the result of these observations, hopes were [illegible] by the mere process of enclosing *usar* and planting trees on the [illegible] portions efficient reserves for the supply of fodder and fuel [illegible] provided at a profit, or at least without serious [illegible] schemes were formulated dealing with as much as [illegible] but eventually four plots were taken up for further experiment. [illegible] plots were as follows:—

Name of reserve	Situation.	Area	Date of [illegible]
		Acres.	
Juhi . . .	5 miles from Cawnpore	102	July 1882.
Amramau . .	4 „ „ „	54	Ditto.
Gursikran . .	7 „ „ Aligarh	718	August 1[illegible]
Cherat . . .	5 „ „ „	242	Ditto.

The original intention was that these plots should be maintained as fuel and fodder reserves; but as has been mentioned in the last chapter the object of the experiment was in part altered, and the greater part of Amramau and Cherat and a portion of Gursikran were brought under the plough, the remainder of Gursikran and the whole of Juhi (except a few small plots) being reserved for the original object of the experiment.

The history of the Juhi enclosure is briefly as follows:—

[illegible] considered [illegible] 6, "R[illegible] [illegible]s, and the [illegible]s is still [illegible]es down [illegible]s, is not [illegible] Annual Report *for 1890-91, paragraph 5,* was "The fact is now conclusively established that the typical grasses cannot be counted on for nutritious fodder, and are coincident and conterminous with the rains .... It is probable that as the quality of the soil improves through enclosure, the character of the grasses will gradually improve; but the

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process, even helped by artificial sowing, must necessarily be slow. In the last rains most of the grasses on the Juhi *usar* were made into hay as an experiment. *It has not yet been sold, as the cavalry* have refused it for their horses ...... The rest of the grass was sold standing at R2-8-0 the acre, and was cut and consumed in a green state"

In 1892 the following notes were recorded:—

"Th

species

makes

grasses

up to 18

more or less valuable grasses. *Dúb* grass (Cynodon Dactylon) is by no means uncommon ... Nine different kinds of grass seed, *specially suited to usar land, were sown, but only one* (Panicum javanicum, *Poir. Syn.* P. Helopus, *Trin*) succeeded well." *Departmental Report for 1891-92, paragraph 5.*

Later notices are generally to the same effect. *Departmental Report for 1894 95, paragraph 15.* The herbage was increasing and better grass apparent; but the quality of the hay continued poor and it was generally refused by the officers of the Commissariat Department as being unsuitable for fodder. Some portion of the grass could always be sold standing, as is natural so close to the great Cawnpore market, but hay-making was gradually restricted. In 1896 we learned the important fact that the grasses on the reserve would not stand a drought, and the herbage did not entirely recover in 1897, when the outturn of hay was only 16 maunds per acre. Next year the season was very favourable, and the outturn was about 40 maunds— a figure which was again reached in 1898. *Departmental Report for 1896-97.*

The process by which better grasses replace poor ones is very slow

The history of this reserve seems to show that if barren land, not on the whole seriously infected with alkali,* is enclosed and kept free from grazing, the natural grasses will grow more or less luxuriantly, and better grasses will establish themselves in places; but the process

* As in the other reserves the soil was not analysed before the experi- ... 'ea of the original condition of ... barren land just outside the ... le salts in the first 6 inches of ... *per cent., most of which was* ... 1 bare soil at a period when evaporation had been very active; and, therefore, it is probable that the salts were largely accumulated near the surface, and that these plots could be cultivated *with success if the salts were kept down The inference* is that the main enclosure was never seriously affected with alkali, except in particular patches.

is very slow. Juhi has been enclosed for 10 years, and the original inferior grasses are still predominant, so that the hay is of bad quality.

The Gursikran enclosure differs from Juhi in having been much more affected with alkali. There is unfortunately no record of the actual quantity of alkali in the surface soil, but there is no doubt that the portion reserved for grass was originally covered in many places with an alkali encrustation. In 1888 Mr. Duthie, the Botanist, wrote: "The prevailing grass is *khar usara*, which over large portions of the ground grows in great luxuriance, unmixed with any other kind of vegetation. Some of the blocks are almost entirely bare and efflorescent; others contain nothing but *usar* grass; whilst in others there is a mixed vegetation, including various sized patches of *dub* grass which appear to be rapidly spreading." *Departmental Report for 1890-91, paragraph 8.* In 1891 it was noted that "the *usar* grass grows very luxuriantly; but there is little demand for it in the green state, and it makes very inferior hay . . The grass was condemned as unsuitable for horses." *Departmental Report for 1893-94, paragraph 16* In the following year "continued improvement" was noticed; and in 1894 the fact was recorded that while the *usar* grass (**Sporobolus arabicus**) still prevailed, *bdi* (**Diplachne fusca**, *Beauv.*) was rapidly spreading, and *dub* (**Cynodon Dactylon**) and *jasera* (**Andropogon annulatus**, *Forsk*) had got the upper hand in places where the water lies. The outturn of hay however was very poor, being only $7\frac{1}{2}$ maunds per acre. *Departmental Report for 1894-95, paragraph 17.* A year later the outturn was 13 maunds of hay per acre, but the hay was a failure as fodder. "Cattle do not eat it with relish, and experiments made by the *Assistant Director* show that they prefer even rice straw to the *usar* hay." *Departmental Report for 1895-96, paragraph 17.* In the following year the rainfall was deficient, and the yield of hay varied from $8\frac{3}{4}$ to 12 maunds per acre. In this year some of the land was used for grazing and showed rapid deterioration—a fact which proves that temporary enclosure is of no permanent use as far as the provision of pasture is concerned.

In 1897, with more favourable rainfall, the yield of hay rose to 15 maunds, but the hay was still condemned as innutritious *Departmental Report for 1896-97, paragraph 30.* In the following year the yield of hay fell to about 10 maunds. Various grasses obtained from New South Wales were tried in this year, but all failed to grow. *Departmental Report for 1897-98, paragraph 28.*

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PRODUCTION OF FODDER. Similar experience at Cherat.

Experience at Cherat, also an alkali reserve, was generally similar to that at Gursikran; but the observations covered a shorter period, as the reserve has passed into private hands.

Slow work: twenty years have been necessary for a slight improvement of fodder and if free grazing is permitted land will revert.

As a result of from 15 to 20 years' work on these reserves, it may be taken as established that by enclosure and prevention of grazing bare alkali land will become covered with grasses, and that in time the better grasses will make way. The yield is however poor in quantity and bad in quality, and even after 20 years we can only count on half a ton of innutritious hay to the acre. It is also established that if after a period of enclosure free grazing is permitted, the land will very rapidly revert to its original state; in other words, it is impossible by this method to turn barren land into pasture.

Better hay might be made by cutting in time.

I am not entirely satisfied that the hay hitherto produced has been as good as possible. The dates of hay-making in the early years of the experiments are not on record; but of late years the grass has generally been allowed to stand too late, and has not been cut until the woody parts have made excessive development: experiments are now in progress with the object of ascertaining whether earlier hay-making will give a more nutritious crop. As was remarked by Dr. Voelcker, it is difficult to get good hay-making weather at the time when the grass is ready for cutting; but bright days occur, and the sun is so hot that the hay can be made in a day.

Ensilage has been made but with disappointing results.

There is usually in populous places a market for the green grass; but the supply of fodder in this case comes just when the market is fullest, and is not available to supplement the fodder supply at the season when it is seriously defective. Consequently when it was seen that the hay was defective, attention was turned to ensilage in the hope that more nutritious feed might be obtained by this process. Ensilage has been made for the past ten years, but for the most part with disappointing results. Thus in 1893-94 the ensilage made from grass was found unfit for use; in 1894-95 it was found "of some use during the cold weather;" and in 1895-96 it was reported to be "generally of poor quantity" Better results were obtained by mixing the grass with chopped fodder, such as *guar* (Cyamopsis psoraloides, *DC*) *impt* or *juar* (Andropogon Sorghum, *Brot*), but it is very doubtful whether this method would be practised by cultivators, who would probably prefer to keep their good fodder separate. The construction of proper silos is out of the question owing to the capital outlay required, and stacking or storing

Cost of constructing proper silos prevents the making of the best ensilage

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in pits involves a good deal of waste, which does not occur when the dry fodder is stored in the ordinary way.

Trial of salt-bushes.

In connection with the question of fodder supply, much interest attaches to the attempts to introduce Australian salt-bushes. *Departmental Report for 1881-82, paragraph 30.* The first trial of these appears to have been made in 1882, when some varieties were tried, one of which (Atriplex nummularia, *Lindl.*) promised to do well.

In 1883-84 the following notes are on record:—

The plants of Atriplex and Chenopodium, received from Sahâranpur, are also thriving. *Departmental Report for 1883-84,* [illegible] Atriplex received in 1882 has [illegible] has produced seed which has been sown; and some young plants thus obtained have recently been planted out. Some seeds of Atriplex nummularia, *Lindl.*, and allied species have recently been received from Sahâranpur and sown in the nursery."

Salt-bushes are killed by the rains.

Unfortunately the further detailed history of these plants is not on record, but all have disappeared. I learn however from Mr. Duthie that the failure of these plants was observed to be due to their inability to live through the wet season when, as already remarked, the surface of the *usar* is slimy mud, and water often stands on it. Salt-bushes thrive best with a light rainfall and on dry soils, and are therefore more likely to succeed on the broken raviny lands where the surface drainage is efficient. Some species which have not yet been tried have however been procured, and these will be planted to see if they can survive the adverse conditions which were fatal to Atriplex nummularia. It is also intended to try along with these certain allied plants which are to be found growing in other parts of this country.

CHAPTER VIII.

Tree-planting on Usar.

TREE PLANTING ON USAR LAND.

Trial of Acacia arabica.

The first attempt on record* to establish a regular plantation on barren land was started in 1874 at Pardilnagar in the Aligarh district, the work being taken up by the Irrigation Department. An area of 10 acres alongside the Sikandra Rao distributary was prepared in seed beds dug three feet deep and filled with good soil or silt to a

* Attempts were made as early as 1863 to plant up *usar* in Oudh, but were discontinued before any results had been obtained.

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level above that of the surrounding land. *Babuls* (Acacia arabica, *Willd.*) were sown, and various other trees planted, and coarse grasses (the kinds are not specified) planted between the trees. The plantation was flooded twice a month for the first year, after which it was not irrigated.

The plantation cost about R50 the acre, and the results were promising up to 1880, when the Conservator of Forests reported that about four-fifths of the land was stocked with healthy *babuls* from 10 to 20 feet high with an occasional *sissoo* (Dalbergia Sissoo, *Roxb*), and that there was a luxuriant growth of grass, while very little alkali was visible. Later reports were however of a different tone. In 1882 the Conservator reported that the trees had not grown much; and by 1886 all the larger trees were gradually dying away, while the younger still looked healthy. In 1888 (the trees being 14 years old and six inches to nine inches in diameter) it was reported that the trees were dying off rapidly.

Trial of Dalbergia Sissoo.

Both dying after 14 years.

Failure of attempt to grow Tamarix.

Mr. C. G. Palmer, C I.E., has supplied me with the following note regarding another early experiment:—

"There was a patch of middling bad *usar*, made much worse by percolation lying in the fork between the Agra canal and the Agra navigation canal. All manner of things were tried on it without any

the whole area with a dense growth of shrub. Before this had been in force very long we had to cut it down and sell it because the dense growth harboured great numbers of pigs. The *jhau* sold at a profit as fire-wood. *Jhau* sends down its roots to a considerable depth, and it is possible that its success in this particular case is due to the clay layer being thin and having been penetrated by the roots. But I think the plant worth trying on swampy *usar*, where the surface can be washed by any form of flooding."

Acacia arabica, Prosopis spicigera and Melia Azadirachta planted at Awa.

The next systematic attempt to grow trees on barren land was made under Mr. Wilson in Awa and elsewhere. *Departmental Report for 1880-81, Appendix D.* Five methods were adopted which are described as follows:—

(i) Holes were dug three feet deep, three feet wide at top and two feet wide at bottom, and then refilled with the soil taken out. Good soil was added to some of the beds.

(ii) Holes were dug of the same size as (i), and the soil was inverted, the earth excavated from one hole being

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thrown into the next. Good soil was added to some of the beds.

(iii) Holes were dug two feet wide and two feet deep and the soil inverted.

Methods of planting.

(iv) Channels were dug one foot deep by one foot six inches broad at the top and nine inches broad at the bottom, and the soil made into a ridge at one side. Seeds were sown on the ridge.

(v) The ground was ploughed and then prepared in ridges six inches high and furrowed six inches deep, the ridges being 10 feet apart.

In the first and second methods good soil was added to raise the seed beds above the level of the *usar* : at first it was added to half the seed beds, but eventually it was added to the remainder, as without it germination was very bad. The seeds sown were *babul* or *kikar* (Acacia arabica, *Willd.*), *chaunkar* (Prosopis spicigera, *Linn.*), and *nim* (Melia Azadirachta, *Linn.*) ;* of these, *babul* did best.

Complete failure when no good soil was added.

The methods numbered (iii), (iv), and (v) were complete failures. *By the first method the seeds came up in 5 per cent. and by the second method in 15 per cent.* of the beds, but they were weakly and were killed off by drought.

In the following year the ridge system was abandoned, and the holes were dug three feet deep, the soil being inverted. *Departmental Report for 1881-82, Appendix II.* A layer of good soil, three inches to 6 inches thick, was put on all the beds. Sowings were effected *in June after the first rain* and the seeds germinated well, but floods in July destroyed the young plants. Re-sowings were carried out by the middle of August, but most were killed in September and October. After this the beds were filled with *babul* which had been raised in nurseries.

Some success with Acacia arabica when good soil was added.

As regards the trees tried, *babul* did best. *Nim* (Melia Azadirachta, *Linn.*) and *shisham* (Dalbergia Sissoo, *Roxb.*) made a good start, but died off in the hot weather. *Chaunkar* (Prosopis spicigera, *Linn.*) did not germinate freely, and on the whole *babul* was preferred.

In 1882 transplanting of *babul* was continued, and the conclusion was drawn that the tree will thrive only in the better kinds of *usar*, and

* Formerly termed *Melia indica.*

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after 1883 little extension was carried out. *Departmental Report for 1882-83, Appendix I.* The plantations then passed with the rest of the estate into the hands of the landowner, and detailed records of their progress are wanting; but the following particulars have been ascertained at a recent inspection.

The land planted by the methods iii to v (described above) is practically bare of trees, except for a few miserable *babuls* or *mahuá* (Bassia latifolia, *Roxb.*) of no value whatever. In the rest of this plantation (known on the estate as "*baghia*") the trees were planted in holes: here the number of trees now in existence is rather greater, but they are not yet of the size for felling and are dying off. The value of the timber standing on the whole of this plantation ($10\frac{7}{8}$ acres) is about R25, to which about R5 may be added for trees which have fallen. There is nothing in the way of grazing: most of the land was quite bare. This, the original plantation, was therefore a failure.

Tree planting succeeded on slightly alkaline land

The next plantation (known as "*khadar*") covered two different kinds of soil. One was a moderate clay, quite workable and not apparently alkaline On this portion the plantation is very fair, though the trees have suffered from overcrowding The other kind of soil was typical *usar* with a good deal of carbonate: on this the plantation has entirely failed, and the land is at present worthless for grazing or anything else.

The plantations in Janauli near Awa, which were made about the same time, have been more successful. The soil is certainly *usar*, and there is a very fair stand of trees, but there are no signs of reproduction (although the plantation is not used for grazing). Apparently in this plantation the holes were dug three feet deep: now examination of the soil shows that the layer of clay is comparatively thin (not more than three feet deep at the spot where I tested it). The holes were therefore dug deep enough to give the roots access to the porous sub-soil, and to this must be attributed the partial success of the plantation. The absence of reproduction must be due to the fact that the seedlings, not having access to the porous layer, are unable to grow in the impervious clay; and this indicates the great difficulty of making such plantations remunerative, as they would have to be replanted periodically.

On the other reserves all kinds of trees were constantly being planted in various ways, but up to 1895 very little success had been

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obtained. As a rule, when the season was favourable, the young trees looked promising for a few years; but the great majority rapidly died out, and a casual inspection of the older trees at Juhi and Gursikran shows that nothing like a regular plantation has been formed, and that a regular supply of fuel or of any economic product has not been obtained. The following conclusions may be definitely drawn from the experiments of the last twenty years :—

CONCLUSIONS WITH REGARD TO TREE PLANTING.

(1) No method of sowing seeds on tilled *usar* land can yield a profitable growth of wood.
(2) Sowing on ridges is equally unsuccessful.
(3) Planting out young trees is a failure wherever the hole in which they are planted is underlaid by a layer of nodular limestone or by a compact stratum of very hard clay.

In all these cases the main cause of failure is identical. If the seed is able to germinate or the young plant to start growth, things go well until the roots have passed through the tilled soil or the earth filled into the hole; but when the roots strike the hard clay they are unable as a rule to penetrate the compact mass, which is practically impermeable to air and water. The necessary conditions of root development being thus absent the tree dies, the exceptions being apparently due to the roots having found cracks or fissures in the hard subsoil through which they have penetrated to the more congenial soil below.

'Thala' system of planting, alkali free earth being added.

Deep thálá system.—Considerations of this nature led to the adoption about 1895 of the method of planting which has come to be known as the deep *thálá* system. As originally introduced, this system required that the holes should be from three feet to four feet deep, and should be filled in with earth free from alkali and mixed with manure: the surface should be raised about a foot above the level of the plain, and healthy seedlings planted out and carefully tended and watered for the first year. Later experience goes to show that no limit should be prescribed for the depth of the holes this must be determined by an examination of the subsoil, and the holes must be dug through the heavy clay, so that the root can penetrate to the coarser material lying below, which is to some extent permeable by air and water.

No limit should be prescribed for depth of holes.

The following statement shows the present results of planting done on this system in the years from 1895 to 1898. The observa-

REPORT ON TREES PLANTED UNDER THALA SYSTEM ON USAR LAND.

tions were made in the cold weather of 1900-1901, when the existing trees were classed as "flourishing" or "struggling":—

Tree.	Season of planting.	Number planted.	Results. Flourishing.	Results. Struggling.	Results. Dead.	Remarks.
I.—Gursikran reserve.—Alkali land						
Babul (Acacia arabica, *Willd.*)	1897	160	20	86	54	Inferior soil used for filling *thálás.*
	1898	13[illegible]	112	10	6	
Shisham (Dalbergia Sissoo, *Roxb*).	1895	20	13	1	6	
	1897	65	...	..	65	Ditto ditto
	1898	40	...	10	30	
Nim (Melia Azadirachta, *Linn.*).	1897	150	23	70	57	Ditto ditto
	1898	111	90	6	15	
Guava (Psidium Guajava, *Linn.*).	1896	36	15	5	16	
	1897	26	1	...	25	
Farásh (Tamarix articulata, *Vahl*).	1898	15	15	...	...	
Ber (Zizyphus Jujuba, *Lamk*) . .	1897	25	4	...	21	
Mahua (Bassia latifolia, *Roxb*) . .	1898	15	1	1	13	
II.—Juhi reserve.—Land not strongly alkali						
Mango (Mangifera indica, *Linn.*).	1895	17	...	...	17	
	1897	28	7	2	19	
Guava (Psidium Guajava, *Linn.*).	1895	43	6	11	26	
	1896	27	..	12	15	
Jamun (Eugenia Jambolana, *Lamk*).	1897	8	8	...	..	
	1898	20	...	..	20	
Babul (Acacia arabica, *Willd.*).	1897	15	14	1	..	
	1898	60	45	11	4	
Dhak (Butea frondosa).	1897	21	13	2	6	
	1898	40	21	4	15	
Nim (Melia Azadirachta, *Linn*) .	1897	15	13	...	2	
Shisham (Dalbergia Sissoo, *Roxb*) .	1897	15	12	...	3	
Ber (Zizyphus Jujuba, *Lamk*) .	1897	15	11	4	...	
Mahuá (Bassia latifolia, *Roxb*) . .	1897	20	...	...	20	
Eucalyptus sp. .	1898	20	4	...	16	

The bad results obtained in 1897 at Gursikran were apparently due to the system tried in that year of refilling the *thálás* with the

earth dug out of them for 2½ feet out of a total depth of four feet. Had this succeeded it would have reduced the cost of the system, but as a matter of fact it was a failure. Leaving these results out of account, it may be said that on distinctly alkaline land *shishams* and guavas were not a success, but that *babul, nim,* and *farash* gave results of promise. *Nim* and *farash* could not pay in practice, but *babul* might. On the Juhi land (not particularly alkaline) mangos, guavas, *jamuns*, and a species of eucalyptus were failures. *Dhak* did moderately, and *babul, nim, shisham* and *ber* were successful. Of this list only *babul* and *ber* can be expected to pay. The entire loss of the *mahuds* planted in 1897 was due mainly to unskilful treatment; the seedlings planted in 1899 were better cared for, and their present condition is as follows:—

TREES WHICH MAY BE GROWN UNDER THE THALA SYSTEM.

	Number.
Planted	160
Flourishing	82
Struggling	23
Dead	55

These figures are sufficiently encouraging to justify perseverance in the attempt to grow this most valuable tree on such soils.

These trials gave such favourable results at the outset that in 1898 a new reserve was taken up at Abbaspur, near Unao, to be used for the propagation of *babul*, the growth of which is of special importance, as the Cawnpore tanneries have for the present almost exhausted the supply of bark in the neighbouring districts. No opinion can yet be given as to the ultimate success of this plantation, but at present the progress made is not discouraging.

It may appear premature to discuss the future application of a method the success of which has not been established, but the following observations may be put on record.—

(*a*) The method is substantially the same as was adopted in the successful plantation at Janauli which is described above, where the holes were dug to a depth sufficient to give the plants access to permeable soil.

(*b*) The method will not apparently ensure a reproduction of the plantation. The seedlings may be expected to die off when they strike the hard pan, while there will hardly be room for fresh seedlings to grow in the original holes.

(*c*) It follows that other things being equal, the most desirable course is to grow trees which will yield a recurring income for

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TREES WHICH MAY BE GROWN UNDER THE THALA SYSTEM.

as long a period as possible rather than those from which the income depends on a short rotation. Of all trees that the small landowner or tenant could raise, *mahud* (Bassia latifolia, *Roxb.*) appears the most desirable in this respect if it can be made to grow.

(*d*) This does not however condemn the attempt to raise *babuls* if one course of the rotation will yield a profit. The cost of planting an acre with 150 trees and maintaining them till established is under R120, with all the disadvantages (already enumerated) which result from Government supervision. Persons working for their own interest could probably effect considerable savings. A fair yield of *babuls* should bring in R200 to the acre when the crop is ready, so that there are not unreasonable hopes that with a continuance of the demand for bark, successful plantations on this system may be financially profitable where facilities for carriage exist. If so, they will incidentally confer great benefits on the locality where they may be established, by supplying timber particularly suitable for agricultural needs, and by affording a plentiful supply of fuel.

(*e*) It does not appear that fuel reserves on a self-supporting basis can be established on this system of planting, except possibly in the immediate vicinity of large towns, or else with trees which yield some other valuable product in addition to the fuel.

Experiments have been made from time to time with a large number of trees or shrubs having special qualities. The following may be mentioned —

Jait (Sesbania ægyptiaca, *Poir.*).—This plant is apparently of no economic value, but was recommended for use in clothing the ground and so preparing it for cultivation. It was found however that though the plant would flourish in soil that had been enclosed and was already covered with vegetation, it would not grow in really alkali soil. It does not therefore serve any useful purpose.

Jhau (Tamarix gallica, *Linn.*).—This plant, well known in the Ganges valley, is of considerable use for thatching, etc. It has grown fairly when planted in Gursikran, but does not yield a heavy enough crop to be commercially profitable.

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Farāsh (Tamarix articulata, *Vahl*).—This has been tried for many years, but has generally failed. It is now growing at Gursikran under the deep *thāla* system, as shown in the foregoing statement. TREES WHICH MAY BE GROWN UNDER THE THALA SYSTEM.

Date Palms (Phœnix dactylifera, *Linn.*).—These were started some time before 1890 at Juhi, Cherat, and Gursikran. Some of them survived; but the progress was very slow, and no crop of fruit has yet been obtained at Juhi or Gursikran. At Cherat the trees are doing well; 132 are in existence of which 72 have fruited: these however appear to have been planted on better patches of land.

Tanning trees.—Four species, Terminalia belerica, *Roxb.*, Terminalia Chebula, *Retz.*, Phyllanthus Emblica, *Linn.*, and Zizyphus Xylopyrus, *Willd.*, were planted at Juhi in 1893: the first and third are flourishing; the others are struggling.

Agave americana, *Linn.*, a fibre plant, was planted as a fence in Juhi in 1893 and subsequent years. It has survived: but the growth is very slow, and there is not as yet anything worth cutting, even on the earliest planting.

Pithecolobium dulce, *Benth.*, which is more familiar to the public under its now discarded name Inga dulcis, *Willd.*, was sown at Juhi in 1896, but failed to germinate.

CHAPTER IX.

Summary.

The methods of treating *usar*, which have given results of positive value, may be summarized as follows. Where manure is available *usar* that is not strongly polluted by alkali may be cultivated. The financial results will depend mainly on the use that could be made of the manure in other ways. A special case is the system of trenching nightsoil in the neighbourhood of towns: in this case the manure is readily available in sufficient quantities to produce excellent results. SUMMARY.

Where manure is not available, the better kinds of *usar* can probably be cultivated by altering their texture by the addition of organic matter, the most satisfactory method being the ploughing in of any crop that can be made to grow during the rains. Where the water lodges at such seasons it will probably be found necessary to grow coarse rice for this purpose, while where other crops will

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SUMMARY.

have a chance *san* hemp (Crotalaria juncea, *Linn.*) *mandua* (Eleusine coracana, *Gaertn.*) or *sawan* (Panicum colonum, *Linn.*, Syn. P. frumentaceum, *Roxb.*) may succeed. The best crops for this purpose have however still to be determined. Where ample means of irrigation exist the growth of *bát* grass (Diplachne fusca, *Beauv.*) may be found a useful preliminary operation.

The method of silting has been shown to be a success where local conditions will permit of its adoption, but it is not applicable to any large portion of the land under consideration.

The alkali of the worst kind of *usar* has been proved suitable for use in making glass, provided the enterprise be on a large scale and under skilled supervision: and it has been used with success for preparing caustic soda for industrial purposes.

The following may be classed as negative results or failures: use of artificial manures, use of gypsum (on financial grounds), enclosure for fodder, propagation of grasses, ordinary methods of planting timber, sowing seeds of timber trees broadcast, and surface drainage.

The deep *thála* method of planting trees is on its trial, and no opinion can be pronounced on it until the young trees now in the ground either die off or come to maturity. The enquiries which have still to be made will deal with the following points:—

(1) The removal of the alkali from the worse *usars*, so as to bring them within the range of the methods of cultivation which are successful on the better classes of land. At present the methods which deserve a trial are the different systems of subsoil drainage and the scraping of the surface at a time when the efflorescence is at its maximum.

(2) The use of lime on land not badly affected with alkali.

(3) The use of nitrate of lime on alkaline land.

(4) The growth of indigenous and imported alkali plants together with a determination of the various plants that grow on unenclosed *usars*.

(5) Determination of the best crops for ploughing in, in order to improve the texture of the soil.

(6) Suitability of the clays for pottery manufacture.

Enquiries in these directions are either in progress or will be started as opportunity offers.

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All communications regarding THE AGRICULTURAL LEDGER should be addressed to the Editor, Dr. George Watt, Reporter on Economic Products to the Government of India, Calcutta.

The objects of this publication (as already stated) are to gradually develop and perfect our knowledge of Indian Agricultural and Economic questions. Contributions or corrections and additions will therefore be most welcome.

In order to preserve a necessary relation to the various Departments of Government, contributions will be classified and numbered under certain series. Thus, for example, papers on Veterinary subjects will be registered under the Veterinary Series; those on Forestry in the Forest Series. Papers of more direct Agricultural or Industrial interest will be grouped according as the products dealt with belong to the Vegetable or Animal Kingdom. In a like manner, contributions on Mineral and Metallic subjects will be registered under the Mineral Series.

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I. HENRY BURKILL,

Assistant Reporter on Economic Products
to the Government of India.

Correction.

THE AGRICULTURAL LEDGER NO. 7 OF 1901.

"*On the seeds of some species of* Brassica *and* Sinapis.

On page 108 (line 8 from the bottom) the epidermal layer of the seed coat of Brassica Napus, *var.* dichotoma is described as detachable; on page 111 (line 14) the same layer is said to be undetachable, in B. campestris, *var.* Sarson, and on page 126 (line 9 from bottom), on page 114 (line 8) and page 127 (line 10) the epidermal layer of B. juncea is stated not to be separable and detachable; *page 116 (line 22) the seed of* B. rugosa *is said to have* a cellular separable mucous epidermis; and a similar statement is made on page 118 (line 20) and on page 127 (line 9 from bottom) of B. besseriana. The translation of the German expressions which occur in the original, *viz.*, getheilte Schleimschicht and nicht getheilte Schleimschicht by the words "detachable," "separable" and "undetachable" is misleading, and I am desired by the translator of Dr. Kinzel's interesting paper to explain that what the author meant to convey is "epidermis divided by transverse septa", or "epidermis not divided."

It may be explained that the difference is one of degree; if the original transverse cell walls of the epidermis retain, as they do in some species, different optical properties to the mucilage added to them, they can be distinguished under the microscope in sections of the ripe seed-coat; if they do not, then their presence can be no longer seen.—(*Editor.*)

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G. I. C. P. O.—No 6.6 R. & A.—25-8-1902—2,230.—C. M. W.

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